Literature Review on the Policies, Practices, Programs, and Other Interventions for Improving the Recruitment, Retention, and Sustained Advancement into Leadership Roles of Women in Specific Science, Technology, Engineering, Mathematics, and Medical (STEMM) Disciplines and at Different Stages in Career Trajectories

Evava S. Pietri[1], Leslie Ashburn-Nardo[1], Corinne A. Moss-Racusin[2], and Jojanneke van der Toorn[3,4]

[1] Indiana University-Purdue University Indianapolis, Department of Psychology
[2] Skidmore College, Psychology Department
[3] Leiden University, Social and Organizational Psychology
[4] Utrecht University, Social, Health and Organizational Psychology

Introduction and Overview of the Problem

There is a well-documented lack of women in many science, technology, engineering, and mathematics (STEM) disciplines (NSF, 2017). This disparity, in addition to reflecting an overall lack of diversity in STEM, presents a problem for the U.S. workforce, because these areas are losing talented prospective workers (PCAST, 2012; White House, 2017). Diverse research teams in STEM lead to higher quantity and quality of outputs (Freeman and Huang, 2014; Page, 2007; 2017). Moreover, having multiple perspectives helps to ensure that scientific research and development tackles issues pertinent across many groups and not simply those that have traditionally dominated STEM fields (Perez, 2019). Broadening participation in STEM fields, therefore, is critical for ensuring a successful and productive STEM workforce.

A variety of factors, however, may be impeding the recruitment, retention, and advancement women in STEM. Because many STEM fields have historically been dominated by men (NSF, 2017), people typically perceive science as a masculine domain and perceive scientists as possessing stereotypically masculine agentic traits (e.g., assertive, ambitious, and competitive) rather than stereotypically feminine communal traits (e.g., warm, supportive, and nice) (Cheryan et al., 2013; Carli et al. 2016; Diekman et al., 2010; Nosek et al., 2007). For example, when researchers instructed study participants to list the traits associated with scientists, men, and women, there was more overlap between the traits participants identified for scientists and men than for scientists and women (Carli et al., 2016). Moreover, individuals are less likely to believe that a woman is scientist when she has a feminine (rather than masculine) appearance (Banchefsky et al., 2016). Thus, there exists a vicious cycle in that the overrepresentation of men in STEM environments both influences and is influenced by the gender-science stereotype. According to social role theory, the observation of more men than women engaging and succeeding in science activities forms individuals' descriptive and prescriptive stereotypes of science as a male domain (Eagly and Wood, 2012; Miller et al., 2015). These stereotypes, in turn, can lead to a variety of adverse consequences that hinder the progress of women in STEM and maintain male overrepresentation in STEM.

To begin this review, we briefly discuss these negative outcomes, including (a) causing bias and unfair treatment toward women at all levels in STEM fields, and (b) making women feel unwelcome and threatened in STEM environments. We then describe interventions that can positively affect these interrelated conditions, by focusing on removing structural barriers to increase the proportion of women in STEM and by decreasing individuals' endorsement of the gender-science stereotype. These interventions can be implemented at multiple levels. In particular, we examine interventions that aim to improve *individuals'* beliefs and attitudes about women in STEM environments, and discuss interventions that can be applied at the *group/relational* level to create better mentoring relationships and classroom environments. Finally, we address this issue at the *organization and policy* level, highlighting the critical role of policy in creating influential and lasting change. Indeed, when there is no organizational incentive for scientists to modify their behavior, efficacious interventions at the individual and group level may have little effect on broadening participation in STEM.

Throughout the review, we discuss how various interventions are efficacious for recruiting, retaining, and advancing women in STEM fields. Interventions that influence recruitment enhance women's interest in STEM, increase the likelihood that women will choose to major in STEM fields, and encourage women to enter STEM careers after college. Techniques to improve retention attempt to decrease the likelihood that women will switch out of STEM majors in college or leave STEM-focused jobs, while strategies to advance women in STEM attempt to ensure that women enjoy the same opportunities as men to receive prestigious awards, promotions, and leadership positions. (See Table 1 for a list of interventions at the individual, group/relational, and organization levels that target recruitment, retention, and advancement.) In this review, we also examine how interventions may impact women with multiple stereotyped identities beyond gender. Finally, we describe how both women and men can help increase gender parity in STEM to ensure that the interventions do not inadvertently create additional service burdens for women scientists.

We acknowledge that broadening the participation of women in STEM likely requires a major cultural shift. To ensure that women feel welcome and are treated fairly in STEM, as a society we need to stop associating men (more so than women) with scientists, and science with masculine traits (more so than feminine traits). Indeed, many of the interventions we describe are necessary and important *because* STEM fields are stereotyped as masculine. If boys and girls were raised in a society that challenged these stereotypic associations from an early age, it would be less critical to alter their perceptions of these fields later in life, for example, by encouraging the belief that STEM fields can be used to help others (Cheryan et al., 2017). However, given that this social change may be slow and will in part require enhanced representation of women in STEM, in this review we outline the interventions that can be successful even in the face of persistent societal stereotypes.

Brief Overview of the Problems that Interventions Aim to Address

The masculine stereotypes associated with STEM fields perpetuate perceptions that women are less competent than men in STEM and lead to unfair treatment of women in STEM fields at all levels of their education and employment. For example, female undergraduate students in science, math, and engineering report higher rates of overt gender discrimination than male students in these disciplines or female students in other majors (Steele et al., 2002). Although when a female candidate is exceptional she may be favored over a male candidate (Williams and Ceci, 2015), experimental research also demonstrates that science professors favor male student applicants and are more responsive to male students' email inquiries about research than inquiries by female students (Milkman et al., 2015; Moss-Racusin et al., 2012). Women already established in STEM also report facing hostile environments (Rosser, 2006; Rosser, 2012), earn less than their male counterparts, and are less likely than male scientists to advance and achieve promotions (Bellas, 1993; Bilimoria and Liang, 2013; Renzulli et al., 2006; Rosser, 2012; Rosser et al., 2006; Wright et al., 2003). Additionally, given feminine stereotypes of communality and expectations of pro-social behavior, women academic scientists are pushed to do more internal service by their colleagues (Guarino and Borden, 2017) and are asked more favors by students (El-Alayi et al., 2018), but are offered fewer career-advancing opportunities than men, for example, being asked to give prestigious colloquia (Nittrouer et al., 2017). Women of color are particularly vulnerable to numerous service and mentoring requests, which harms their research productivity and advancement (Harley, 2008; Turner et al., 2011).

Aside from direct, overtly negative treatment, women can and do feel unwelcomed and threatened in STEM environments given these environments' strong societal association with masculinity. This threat occurs in a variety of ways. First, the mismatch between the stereotypes associated with women and scientists can cause women to feel disconnected from and to not identify with STEM fields (Cundiff et al., 2013; Settles et al., 2016; Stout et al., 2011). Furthermore, this perceived lack of fit can make women vulnerable to social identity threat in STEM—the fear that their gender identity will be devalued in STEM environments (Steele et al., 2002). Many years of research have linked social identity threat to a variety of harmful outcomes for women in STEM (Boucher and Murphy, 2017; Murphy and Taylor, 2012). For instance, social identity threat can result in women experiencing belongingness concerns in STEM environments (Cheryan et al., 2013; Murphy et al., 2007), which can lead to lower grades in STEM classes (Walton et al., 2015) and avoidance of these fields (Lewis et al., 2017). Social identity threat can also undermine women's sense of self-efficacy in STEM, the belief that one is not competent in and will fail in STEM environments (Cheryan et al., 2011; Murphy and Taylor, 2012). Finally, social identity threat may trigger stereotype threat concerns, the fear that one's actions and performance will be viewed through the lens of a negative stereotype and that one may inadvertently confirm the stereotype (Steele, 1997; Steele and Aronson, 1995). Worrying about confirming a stereotype consumes valuable cognitive resources, which ultimately can hinder performance and lead to lower grades in STEM courses (Schmader et al., 2008; Schmader and Beilock, 2012; Shapiro and Williams, 2012). To summarize, at all entry and advancement points, women in STEM have been shown to face significantly more barriers to success than their male counterparts due to the pervasive masculine stereotypes in STEM. Below we discuss interventions to address these many hurdles, as well as the necessary policies and organizational changes to ensure these interventions are implemented and successful.

Interventions to Change Individual Level Beliefs and Attitudes

A variety of effective interventions have focused on changing individual-level beliefs and attitudes in order to promote more inclusive environments for women in STEM. Focusing on the problems we highlighted above, we discuss interventions to address biases and promote more positive attitudes and perceptions of women in STEM, to alter personal perceptions of STEM fields, and to alleviate the harmful impact of social identity threat on women in STEM.

Addressing the Harmful Biases Impeding Female Students' and Scientists' Success

Because the masculine stereotypes associated with science can lead to bias and discrimination toward women in STEM, it is critical that interventions work to change individuals' (i.e., scientists' and other students') perceptions and treatment of women in these fields. Eradicating theses biases would ensure that scientist gatekeepers are not inhibiting women's opportunities for advancement in STEM (Moss-Racusin et al., 2012). Making gender equality and fair treatment the norm in STEM would also boost women's engagement and interest in these fields (Moss-Racusin et al, 2018).

An assortment of techniques are described in the literature on stereotyping, prejudice, and attitude change that effectively reduce bias and break implicit stereotype associations (e.g., break the implicit association between men and science). As one example, researchers have demonstrated that exposure to counter-stereotypical exemplars (i.e., people who deviate from their group stereotypes) reduces implicit biases (Columb and Plant, 2011; Dasgupta and Greenwald, 2001; Plant et al., 2009), and this strategy may be particularly relevant for advancing women into leadership positions in STEM. Specifically, researchers found that presenting participants with pictures and descriptions of women leaders resulted in lower implicit male-leadership associations compared to control participants who did not learn about women leaders (Dasgupta and Asgari, 2004). Given the benefits of seeing counter-stereotypical exemplars, it is unsurprising that many years of research demonstrate the benefits of meaningful contact and interactions with these exemplars for diminishing bias (Dovidio et al., 2003; Pettigrew and Tropp, 2011). Having "virtual" contact via television or movies (Schiappa et al., 2005), or simply imagining a positive contact experience can also result in lower prejudice and stereotyping (Crisp and Turner, 2009). For instance, researchers found that instructing participants to imagine a strong, capable woman (compared to picturing a weak woman or nothing), decreased their implicit stereotyping of women as weak and men as strong (Blair et al., 2001). Beyond visualizing interactions with female scientists, actively taking the perspective of female leaders and scientists or "walking in their shoes" also may reduce bias toward women in STEM (Galinsky et al., 2005; Galinksy and Moskowitz, 2000; Todd et al., 2011).

Another way for an individual to counteract stereotypical thoughts is to think "no" or "this is wrong" when a stereotype is activated (e.g., a man comes to mind when thinking of a scientist), or to positively affirm counter-stereotypical thoughts (i.e., thinking "yes, that's right") (Gawronski et al., 2008; Johnson et al., 2018; Kawakami et al., 2000). In a related experiment that was particularly relevant to advancing women into leadership positions, researchers presented participants with a picture of a man or woman and two words describing traits. The researchers then instructed participants to choose the trait that was *not* stereotypically connected with the gender of the person in the picture (e.g., participants were told to choose "strong" for a woman or "weak" for a man). Compared to participants in a control condition, participants who underwent this training were less likely to discriminate against female job candidates for leadership positions (Kawakami et al., 2006).

Taken together, previous research studies illuminate numerous strategies for reducing personal bias and weakening the masculine trait (and not feminine trait) connection with STEM. However, while these many techniques are promising for addressing the gender disparity in STEM, a single training may not lead to lasting change and may only diminish bias for a few hours or days (Lai et al. 2014; Lai et al., 2016). It also is important to note that interventions that only aim to break implicit associations may not be sufficient for changing discriminatory behaviors. Rather, it is critical to help people recognize their personal biases and unfair actions in order to motivate equitable treatment of others (Burns et al., 2017; Klonis et al., 2005). Finally, the experiments described above were not conducted with scientists and STEM faculty and typically employed college student samples.

Bias literacy trainings. Diversity researchers and practitioners have developed and validated various bias literacy interventions to enhance knowledge of sexism and discrimination toward women in STEM, which have been used with scientists, STEM faculty, and researchers (Moss-Racusin et al., 2014; Sevo and Chubin, 2008). For instance, it has been shown that providing individuals with information about the harmful nature of benevolent sexism (treating women as delicate objects that need to be protected and cherished) reduces endorsement of benevolent sexist beliefs (Becker and Swim, 2012), and training individuals to notice subtle instances of gender bias in their everyday experiences leads to lower sexism scores (Becker and Swim, 2011). An interactive game called Workshop Activity for Gender Equity Simulation (WAGES) subtly exposes individuals to the common challenges encountered by women at work via an interactive game and is also an efficacious bias literacy intervention. Compared to controls, participants who played WAGES reported increased knowledge of gender inequity and perceived sexism as harmful (Cundiff et al., 2014; Zawadzki et al., 2012). By changing individual-level attitudes and promoting fair treatment toward women in STEM, bias literacy interventions have the potential to reduce hostility in STEM environments and encourage the retention of female scientists.

Numerous other bias literacy interventions have been developed and validated specifically with STEM faculty. As one example, the National Science Foundation ADVANCE-funded Women in Science and Engineering Leadership Institute at the University of Wisconsin – Madison developed and validated extensive workshops for promoting bias literacy. In a randomized control trial design, these researchers assigned departments in STEMM (STEM and medicine) to either undergo the workshop or be part of a waitlist control group. Relative to those in the control departments, faculty who underwent the workshop reported higher knowledge of gender bias and higher awareness of their own personal biases (Carnes et al., 2012; Carnes et al., 2015). Another shorter 20-minute workshop (unrelated to the first), which also provided information about sexism in medicine and leadership, reduced participants' implicit stereotypes associating men with leadership relative to people who did not take part in this workshop (Girod et al., 2016). This shorter intervention was implemented among faculty in medicine, and hence was relevant to the goal of advancing women into leadership positions in medical schools.

Another interactive and workshop-based bias literacy intervention focused on improving the recruitment of women STEM faculty. In particular, during this University of Michigan National Science Foundation ADVANCE-funded two-hour faculty recruitment workshop (not limited to STEM faculty), faculty participants learned about social science research on implicit stereotyping and bias and received tips for conducting more equitable faculty searches (Sekaquaptewa et al., 2019). Compared to those who did not attend the faculty recruitment workshop, faculty who took part indicated having more positive attitudes toward and higher intentions to use strategies that help create equitable searches (Sekaquaptewa et al., 2019).

Another ADVANCE-funded initiative at the University of New Hampshire developed the Gender Equity and Recruitment of Underrepresented People (GEAR UP) interactive theater training, which also had the goal of recruiting women into STEM (Shea et al., 2019). This workshop began with a 20-minute play demonstrating instances of implicit bias in the search committee hiring process. Audience members then participated in a carefully facilitated discussion that encouraged them to notice the bias throughout the play. GEAR UP was tested among faculty generally with an emphasis on STEM departments, and it increased the faculty members' awareness of biases during the search process relative to scores before the workshop (Shea et al., 2019).

Many of the previously described bias literacy interventions (particularly those that have been validated with STEM faculty) relied on trained facilitators and/or in-person sessions. In more recent work, researchers have developed a bias literacy intervention that does not require an in-person workshop or facilitators. Relying on short high-quality videos, Video Interventions for Diversity in STEM (VIDS) present evidence of gender bias that can easily be viewed online and consist of two presentational styles. The first set of videos contains six entertaining narratives and entails emotionally evoking stories. The second set of six videos, the expert interviews, features interviews with a supposed psychology professor. Previous research has found that narratives and expert interviews are efficacious persuasive tools (Green and Brock, 2000; Pornpitakpan, 2006), and hence both of VIDS's presentational styles were successful interventions for enhancing gender bias literacy and reducing sexism among faculty across STEM fields (Hennes et al., 2018; Moss-Racusin et al., 2018; Pietri et al., 2017).

Although encouraging the awareness of gender bias in STEM is an important precursor for sparking action, to effectively change behaviors, interventions also must provide clear strategies for reducing bias and promoting equity (Carnes et al., 2012; Moss-Racusin et al., 2014). Indeed, raising awareness of bias alone may not help—or can even harm—self-efficacy to prevent bias and may inadvertently encourage beliefs that biases are fixed (Hennes et al., 2018). Individuals who do not feel self-efficacious or think that biases can never change are less likely to combat unfair treatment in themselves and others (Bandura, 2004; Carr et al., 2012; Floyd et al., 2000; Neel and Shapiro, 2012; Rattan and Dweck, 2010). Consequently, the bias literacy workshop developed by Carnes et al. (2012; 2015) provided a list of validated techniques to help attendees reduce their personal implicit biases (e.g., interacting with counter-stereotypical exemplars or perspective-taking). At the conclusion of the workshop, participants wrote down specific actions they intended to take in order to be more equitable because such goal-setting increases the likelihood that individuals will alter their behavior after a diversity training (see Madera et al., 2013). As a result, the Women in Science and Engineering Leadership Institute workshop not only enhanced awareness of bias, but also increased feelings of self-efficacy and behavioral changes to tackle bias. In another example, compared to VIDS alone, VIDS paired with a list of concrete tips to create inclusive STEM classroom environments increased STEM faculty's self-efficacy to combat bias in their classes and their belief that sexism is not fixed (Hennes et al., 2018). Providing strategies to address gender bias and promoting the message that gender bias can be overcome also helps to ensure that bias literacy interventions do not inadvertently increase feelings of threat (i.e., decreased belonging in STEM) among women (Pietri, et al., 2018a).

Enhancing individuals' recognition of their personal biases does not always require carefully designed workshops or interventions. During everyday interactions, people can point out or confront unfair treatment or statements toward women in STEM. Although this technique lacks the formality of an official training, it is nevertheless successful at increasing awareness of personal biases, reducing bias, and ultimately leading to more equitable future behavior (Ashburn-Nardo et al., 2014; Ashburn-Nardo et al., 2008; Czopp and Ashburn-Nardo, 2012; Czopp and Monteith, 2003; Czopp et al., 2006; Drury and Kaiser, 2014; Park et al., 2018). Confrontation of unfair behavior is particularly effective when done by people in leadership roles or by men, which demonstrates the benefits of training leaders and men to confront sexism in STEM (Ashburn-Nardo et al., 2014; Drury and Kaiser, 2014). Bias literacy interventions (such as VIDS) may be one tool to effectively inspire individuals to confront unfair treatment in STEM (Pietri et al., 2017).

Increasing intersectional awareness. Many of the interventions and workshops discussed above are successful at reducing negative attitudes and increasing awareness of bias toward a variety of negatively stereotyped groups in STEM, not only women. For instance, Devine et al. created a training to address racism, which employed many of the same techniques as the workshop developed by the team at the Women in Science and Engineering Leadership Institute (Carnes et al., 2012; Carnes et al., 2015). Compared to those who did not undergo the training, participants who took part in this multicomponent intervention had increased awareness of prejudice and reduced explicit and implicit prejudice toward black individuals (Devine et al., 2012; Forscher et al., 2017). Thus, one possible technique for encouraging equitable treatment of women with multiple negatively stereotyped identities in STEM is to combine different interventions, using interventions that address biases toward women, black individuals, and others.).

However, this approach may not address all of the biases facing women with additional identities because stereotypes often intersect to create unique challenges. As one example of this issue, black women encounter different adversity than that experienced by either black men or white women. Compared to their male and white counterparts, black women are penalized more for failure (Rosette and Livingston, 2012) and are more likely to encounter invisibility bias (i.e., going unnoticed and having their ideas and contributions attributed to black men or white women) (Sesko and Biernat, 2010). Consequently, it is important to not only raise awareness of bias toward multiple groups, but to also enhance recognition of the specific biases directed toward women with multiple intersecting identities (Curtin et al., 2015). Previous work has found that raising intersectional bias awareness in college classes can encourage positive changes in attitudes and beliefs (Case, 2017; Case and Lewis, 2017; Case and Rios, 2017). However, future work might continue to validate interventions to address intersectional biases via control laboratory experiments as well as through large scale field experiments with STEM faculty.

Dispelling Stereotypic Misconceptions about STEM

In addition to masculine science stereotypes leading to the unfair treatment and discrimination of women in STEM, these stereotypes also can result in women feeling unwelcome and threatened in STEM environments. In particular, these stereotypes can lead to people incorrectly believing that all scientists are nerdy men who work alone and only care about research (Cheryan et al., 2013). In reality scientists often work in teams, do research focused on helping others, and have hobbies outside of work. Thus, a variety of successful interventions focus on changing these misperceptions of STEM in order to promote belonging, self-efficacy, success, and interest in these fields, particularly among women (Cheryan et al., 2017). Such interventions have modified STEM environments or materials to suggest that these disciplines value feminine (rather than masculine) and communal (rather than agentic) traits (Cheryan et al., 2015; Cheryan et al., 2014). Many of these techniques have focused on the goal of recruiting women in STEM majors, careers, and companies. For instance, researchers have found that including neutral objects (e.g., a nature poster) instead of masculine objects (e.g., a Star Trek poster) in computer science classrooms increased female college students' sense of belonging and interest in computer science (Cheryan et al., 2011; Cheryan et al., 2009). Additionally, incorporating feminine and counter-stereotypical images compared to masculine images into a chemistry textbook improved female students' comprehension of a chemistry lesson (Good et al., 2010). Outside of the classroom, companies also can dispel the masculine STEM association by using communal traits in their job advertisements (Gaucher et al., 2011). Indeed, female students report higher anticipated belonging and interest in working in occupations that are advertised as requiring feminine and communal traits rather than masculine and agentic traits (Gaucher, et al., 2011).

Diekman et al.'s role congruity model posits that one reason women avoid STEM fields is because they do not see their values (e.g., helping others) as matching the values and goals of scientists (e.g., fame and success) (Diekman et al., 2010; Diekman et al., 2011; Weisgram et al., 2011; Brown et al., 2018). Therefore, successful interventions to alter women's personal perceptions of STEM often incorporate the message that STEM fields value and fulfill communal goals such as improving society and working with others (Diekman et al., 2011). For instance, researchers have found that encouraging individuals to contemplate why as opposed to how scientists conduct research in STEM (e.g., improving society versus running experiments) increases beliefs that STEM careers broadly satisfy communal ambitions and enhances male and female students' positive attitudes toward those careers (Steinberg and Diekman, 2018). In a less subtle intervention, when biomedical research was explicitly described as aiming to improve lives and society, male and female students' motivation to conduct biomedical research was sparked (Brown et al., 2015). Similarly, when class lectures are structured to emphasize how STEM research and careers help others, female high school students believe that STEM careers afford communal goals, and they indicate higher interest in these careers (Fuesting et al., 2017).

Scientists also can personally emphasize how their profession satisfies their communal motives (Clark et al., 2016; Fuesting and Diekman, 2017; Weisgram et al., 2011). As one example, watching female scientists present on the altruistic aspects of their research increases adolescent girls' interest in science (Weisgram and Bigler, 2006). Learning about how a scientist's daily tasks involve working with and helping others (as opposed to working alone) also encourages female college students' attraction to STEM fields (Diekman et al., 2011). Finally, female STEM majors report being more interested in working with a faculty mentor who values communal goals compared to a mentor who values agentic goals (Fuesting and Diekman, 2017). Taken together the above research provides compelling evidence that presenting STEM fields (including biomedical sciences and computer science) as communal and feminine enhances female students' interest in STEM and encourages recruitment of women in STEM. It is noteworthy that many of these interventions enhanced both female *and male* students' interest in STEM (see Brown et al., 2015; Steinberg and Diekman, 2018), suggesting that these strategies benefit any student who values helping others and do not inadvertently dissuade men from entering STEM careers.

Female role models. Female scientist role models (a scientist that women feel similar to and aspire to be like; Gibson, 2004) also can change women's personal beliefs about STEM fields and break their STEM masculine associations (Young et al., 2013). In addition to changing perceptions of STEM fields, when women interact with scientist role models, women also picture themselves becoming the scientists in the future, altering their possible future selves or their representations of who they could become in the future (Lockwood and Kunda, 1997; Markus and Kitayama, 2010; Markus and Nurius, 1986). As a result, multiple theories have highlighted the benefits of role models for encouraging women's attraction to STEM.

For example, the motivational theory of role modeling (Morgenroth et al., 2015) posits that because individuals aspire to be like successful similar others, role models act as inspiration to encourage individuals to value certain domains and be attracted to those fields (Paice et al., 2002). This model further asserts that by identifying with role models, individuals view role models as evidence that it is *possible* to succeed in a given area and thus feel self-efficacious (Lockwood and Kunda, 1997). Dasgupta's (2011) stereotype inoculation model further argues that when women feel similar to scientist role models, the role models inoculate against threatening stereotypes about women in STEM and indicate that women will be valued and belong in STEM environments (Dasgupta, 2011; Stout et al., 2011). Critical to both theories is that women must identify with the role model for the role model to be inspirational. In general, women are more likely to identify with and feel more inspired by female than male role models (Lockwood, 2006). Consequently, researchers have found that even brief exposure to a woman scientist role model enhances female students' identification with and interest in STEM (Ramsey et al., 2013; Stout et al., 2011). As one example relevant to the early stages of recruitment, when middle school girls were instructed to reflect on and write about a role model with whom they interacted during a summer science program, they had an enhanced sense of fit in STEM relative to students who wrote about their best friends (O'Brien et al., 2017). In another experiment at the college level, researchers randomly assigned female engineering majors to learn about successful male engineers, female engineers, or innovative discoveries in engineering (with the latter the control information). Relative to students who learned about male engineers or control information, those who read about female engineers indicated higher self-efficacy and career motivation in STEM. This finding is pertinent to recruiting female engineering majors into the STEM workforce as well as retaining female engineers from college into STEM careers. With regard to retaining female scientists after college, having supportive role models in their workplaces also encourages belonging among women established in their STEM careers (Richman et al., 2011).

It is important to note that there are certain characteristics that result in female scientists being more or less effective for recruiting women into STEM. For instance, researchers found that when female students who were not currently computer science majors interacted with a stereotypical computer scientist who was female (i.e., had masculine traits), these students reported lower self-efficacy and belonging in computer science than students who interacted with a male scientist or female counter-stereotypical scientist or who did not interact with a scientist at all (Cheryan et al., 2011; Cheryan et al., 2012). Specifically, female students felt less similar to the stereotypical computer scientist than to the counter-stereotypical computer scientist, which, in turn, related to lower belief of success and belonging (Cheryan et al., 2011; 2012). It is thus unsurprising that female scientists who clearly value communal goals (as opposed to those who value agentic goals) are more likely to spark female students' interest in STEM (Clark et al., 2016; Fuesting and Diekman, 2017). However, at the same time it is crucial that the role models do not appear overly feminine. Because of the masculine stereotypes associated with STEM, being a feminine scientist may seem highly unattainable, particularly among female students with low STEM identification (Lockwood and Kunda, 1997). Supporting this possibility, Betz and Sekquaptewa (2012) found that relative to interacting with a gender-neutral scientist, middle school girls reported lower expectations of success, belief in their own abilities, and interest in math after interacting with a highly feminine scientist. Finally, women relate better to female scientists when they believe the scientists have had similar experiences and past challenges as themselves (Asgari et al., 2012; Pietri et al., 2018b).

Requiring female scientists to act as role models may create extra service requirements for these scientists (i.e., by having them serve on panels or give guest lectures) and harm their research productivity (Guarino and Borden, 2017). Consequently, a strategy to ensure that women see relatable counter-stereotypical female scientists without burdening women in working in STEM is to ensure that female scientists are featured in movies and television shows. The “Scully effect” is one demonstration of benefits associated with women scientists’ representation in popular media. Specifically, researchers found that women who consistently watched the X-files in middle school and were exposed to the character, scientist Agent Dana Scully, were more likely to express interest in STEM, major in a STEM field, and work in a STEM profession relative to women who did not watch the X-files (GDIGM, 2018). In related work, researchers found that watching 10 short television clips featuring men and women scientists encouraged both male and female adolescents to picture themselves becoming scientists in the future (Steinke et al., 2009).

Male allies. To further alleviate the heavy service expectations for female scientists (Guarino and Borden, 2017), it is critical that male scientists play an active role in changing perceptions of STEM (Akcinar et al., 2011). Indeed, male scientists can inspire women’s self-reported interest in STEM and promote the recruitment of female students into STEM by not conforming to agentic masculine stereotypes and by describing how their work fulfills communal goals (Cheryan et al., 2011; Cheryan et al. 2013; Clark et al., 2016; Fuesting and Diekman, 2017). Women also may feel more welcome in STEM environments that have supportive male allies. For instance, researchers found that when black female STEM majors perceived having multiple ally professors and care about helping black women succeed in STEM, they reported higher belonging in STEM (Johnson, Pietri, Fullilove, Mowrer, 2019). This study suggests that allies may help retain female students in STEM majors by ensuring that students feel welcome in STEM. Additional work has found that white female participants performed better on a spatial ability task when they thought that task was created by an expert also from a negatively stereotyped group (i.e., a black male expert) than by a white male expert (Chaney et al., 2018). This enhanced performance was in part explained by participants’ perceptions that the expert from a negatively stereotyped group was an ally who believed women have strong spatial abilities (Chaney et al., 2018). It is important to note that saying one is an ally and has a positive attitude toward a group may be beneficial, but is not sufficient to elicit trust from members of that group (Dovidio et al., 2006; Hebl et al., 2009). Rather, one may need to perform a series of actions to signal commitment to helping that group (Ashburn-Nardo, 2018; Brown, 2015; Droogendyk et al., 2016; Ostrove and Brown, 2018), and hence researchers should continue testing how male scientists can effectively signal that they care about helping women in STEM and are allies.

The importance of intersectional identities. The agentic traits associated with scientists not only align with stereotypes about men, but also with stereotypes about white individuals (Dixon and Rosenbaum, 2004; Dovidio et al., 1986; Fazio et al., 1995; Gaertner and McLaughlin, 1983), individuals from higher socioeconomic statuses (Fiske, 2010; Kay and Jost, 2003), and individuals without disabilities (Cuddy et al., 2007; Fiske et al., 2002). Moreover, beyond picturing scientists as being men, individuals may also imagine scientists as heterosexual and cis-gendered men (Cech and Waidzunas, 2011; Yoder and Mattheis, 2016). Women with multiple identities that do not match this heterosexual, white, abled-bodied male stereotype are at heightened risk for feeling unwelcome in STEM environments. As one example, recent work demonstrated that black and Latina female college students reported higher threat and disengagement than white female students in STEM class (Casad et al., 2018). And the same may be the case for sexual-minority men. A longitudinal analysis of national survey data by Hughes (2018) indicated that male sexual-minority students were less likely to persist in STEM fields compared to their male heterosexual peers, whereas the opposite was the case for female sexual-minority students compared to their female heterosexual counterparts. Given the stereotypical image of gay men as feminine and gay women as masculine, these findings further underscore the detrimental effects of masculine stereotypes in STEM. Interventions to positively alter perceptions of STEM (i.e., that STEM support communal goals), therefore, may be particularly beneficial for women with multiple negatively stereotyped identities in STEM. Moreover, the advantages of interventions for women also may transfer to other marginalized groups in STEM (Chaney et al., 2018), including sexual-minority men.

Indeed, aside from helping women, researchers have demonstrated that encouraging perceptions that STEM fields appreciate communal traits and goals benefits other underrepresented groups in STEM. With regard to recruitment, underrepresented minorities

(URMs), and first-generation college students (i.e., whose parents did not attend college) are more attracted to STEM careers when they believe science can be used to helps others (Allen et al., 2015; Smith et al., 2014; Thoman et al., 2015). Likewise, first-generation college students do better academically when their university environment is presented as a community rather than focused on personal success (Stephans et al., 2012). Harackiewicz et al. found that encouraging students to think about how STEM course content can be used to help others improved the academic performance of first-generation and URM students, and was most helpful for students who were *both* URM and first generation (Harackiewicz et al., 2016). These findings suggest that students with multiple stereotyped identities in STEM may benefit more than those with a single stereotyped identity from interventions encouraging them to view STEM fields as respecting communal goals.

Although initial evidence suggests that interventions to change personal beliefs about STEM fields might be particularly helpful for women with multiple stereotyped identities, this is an important question for future research. In addition to viewing STEM as appreciating feminine traits, women of color may also require evidence that STEM values their specific cultures, for example, by seeing culturally relevant examples in STEM classes (Fryberg et al., 2008; Garcia and Okhidoi, 2015). Moreover, women with disabilities may worry that STEM environments will not be accessible to them and, as a result, may benefit from interventions to specifically promote perceptions that STEM classes and laboratories accommodate all students (Hemmingson and Borell, 2002; Guardino and Antia, 2012; Martin et al., 2011). Finally, preliminary research suggests that better representation of women in STEM is associated with greater inclusion of those who are stereotyped as not conforming to gender roles in that LGBTQ+ scientists working in STEM fields with better representation of women were more likely to disclose their identities to their colleague (Yoder and Mattheis, 2016). However, it will be critical for future work to continue exploring how these interventions impact individuals who identify as gender nonbinary.

In contrast to encouraging personal views that STEM values communal goals and traits, role models may not be a “one size fits all women” intervention; even relatable and communal white female scientists may not be effective role models for women with multiple stereotyped identities (Pietri et al., 2018c). As one illustration of this possibility, because black women are more sensitive to the possibility of racism than sexism (King, 2003; Levin, Sinclair, Veniegas and Taylor, 2002), they identify more strongly with a black male or female scientist than a white female scientist (Johnson et al, in press; Pietri, et al., 2018c). As a result, black women anticipate more belonging in a STEM-oriented company (Pietri et al., 2018c) or school of science and technology (Johnson et al., 2019) when they learn about a black female or male scientist at the company or school compared to when they learn about a white female scientist. White female scientists, therefore, may not function as role models to recruit black women in STEM (Johnson et al, 2019; Pietri, et al., 2018c). With regard to retention, researchers found that for black female college students majoring in STEM, having black women role models related to higher belonging in STEM, whereas having white women role models did not predict belonging in STEM (Johnson et al., 2019). Future research should continue to explore situations when white female scientists do or do not act as role models for women with multiple negatively stereotyped identities in STEM. Nonetheless, this initial work suggests that when presenting women with role models to alter their future selves and spark self-efficacy, belonging, and interest in STEM, it will be important that these interventions feature female scientists with multiple negatively stereotyped identities aside from gender.

Changing Personal Beliefs about Innate Talent or "Brilliance" in STEM

In addition to stereotyping STEM fields as masculine, many people also believe that many STEM fields require innate talent for success, or "brilliance" (Leslie et al., 2015; Meyer et al., 2015). This intrinsic brilliance stereotype again does not align with stereotypes about women, and individuals typically do not perceive women as being born with the unique ability to shine in the math and sciences (Bennett, 1996; Dweck, 2007; Kirckcaldy et al., 2007; Tiedemann, 2000). As a result, interventions that encourage people to view STEM as not requiring innate talent help to create more welcoming environments for women in STEM. Similar to the techniques that promote perceptions that STEM fields value communal goals, many of the interventions that emphasize the importance of hard work in STEM aim to recruit women in STEM majors, careers, and companies. For example, when a field is described as requiring brilliance rather than hard work for success, women are less interested in that field, imagine being different from the prototypical person working in that discipline, and anticipate more anxiety, lower belonging, and lower self-efficacy in that field (Ban et al., 2018). Female STEM graduate students also may worry that in male-dominated disciplines they will have to work harder to thrive than their male counterparts (Smith et al., 2013). However, researchers found that when a fictional "eco-psychology" graduate program clearly indicated that all students (men and women) in the program work hard to flourish and earn accolades, women were more interested in that program relative to one that did not normalize effort and hard work (Smith et al., 2013).

Leadership in the private sector. Outside of the school setting, women also are more attracted to companies which emphasize that employees can grow and improve in their organization than to companies that do not highlight this philosophy (Emerson and Murphy, 2015). Related to this, stereotypes of women's innate brilliance and talent also may hinder their advancement into top leadership positions. Individuals tend to view "being visionary" as a critical characteristic for successful leaders and perceive women leaders as having less "vision" than male leaders. Rather than relying on this somewhat ambiguous "vision," which prioritizes organizational strategic direction and inspiring employees, women leaders tend to focus on process and making decisions based on concrete evidence and careful analyses (Ibarra and Obodaru, 2009). Consequently, in order to ensure that women advance into top leadership positions in STEM, it may be helpful to change beliefs about what is required for leadership success and not prioritize this somewhat vague notion of "vision."

Valuing continual improvement. Another strategy to enhance women's interest and comfort in STEM fields is to ensure that women believe skills and intelligence are consistently changing and improving. Indeed, the more that female high school students believe they have the capacity to be successful after setbacks, the more likely they are to major in physics, engineering, mathematics, and computer science in college (Nix et al., 2015). With regard to STEM ability, women can either have a growth or incremental mindset (i.e., have beliefs that they can improve and get better) or a fixed/entity mindset (i.e., have beliefs that their ability is fixed and cannot change) (Dweck et al., 1995). Across many years of research, Dweck et al. have demonstrated that having a growth mindset increases academic performance among middle school, high school, four-year college, and community college students (see Dweck, 2006; Yeager and Dweck, 2012 for a review). For example, researchers found that middle school students with a growth mindset had higher self-efficacy and learning-focused goals, and also found that middle school boys were more likely to have growth mindsets than girls (Chen and Pajares, 2010). Moreover, compared to those who have a fixed mindset, female college students with a growth mindset about math ability indicated higher belonging in math, reported more attraction to math careers, and earned higher grades in math classes (Good et al., 2012).

Researchers have demonstrated the benefits of implementing short mindset interventions, which provide evidence that ability is not fixed and can improve. For instance, middle school students who took part in a workshop discussing how the brain is malleable and intelligence is not fixed had increased motivation in math and improved math grades relative to students who did not complete the workshop (Blackwell, Trzesniewski, Dweck, 2007). This mindset intervention was effective because it encouraged students to value learning and effort and respond more positively to challenges (Blackwell et al., 2007). In another example, female seventh grade students who were mentored by college students promoting a growth mindset performed better on standardized math tests than students who did not receive this growth-focused mentoring (Good et al., 2003). Therefore, having female middle school students undergo a growth mindset intervention may be one way to recruit them into STEM majors.

In addition to female students, mindset interventions help other students who traditionally have been underrepresented in STEM. For example, relative to those in a no-intervention control condition, black college students who underwent a growth-mindset intervention had higher academic motivation and higher grade point averages (Aronson et al., 2002). In a larger-scale experiment involving 90 percent of first-year college students attending a public university, researchers found that compared to students in a control group, a mindset intervention increased the grades of Latinx students and reduced the achievement gap between Latinx and white students. Testing the effectiveness on this intervention across multiple academic environments (a high school, public university, and selective private university), researchers also demonstrated that this growth-mindset intervention improved the academic performance of first-generation and URM students relative to those who did not complete the intervention (Yeager et al, 2016). Taken together, this research provides compelling evidence that mindset interventions are scalable—can be implemented across multiple academic contexts—and have the potential to be beneficial for women with multiple negatively stereotyped identities in STEM.

Values-Affirmation Interventions to Alleviate the Harmful Consequences of Social Identity Threat

The previous section focused on modifying women's personal beliefs about STEM culture (e.g., as fulfilling communal goals, as requiring hard work for success). However, it may not always be possible to alter women's perceptions of these fields, particularly in STEM environments with an overrepresentation of men (Murphy et al., 2007). When the masculine STEM stereotype is prevalent, women may experience social identity threat and the associated negative outcomes (Murphy and Taylor, 2012). Consequently, researchers have developed various interventions to protect against this threat, and these interventions can be successful even while women perceive STEM fields as masculine. It is also important to note that reducing social identity threat ultimately can change perceptions of STEM disciplines and promote beliefs that these disciplines value communal goals (Smith et al., 2015).

Values-affirmation interventions. Having women undergo values-affirmation interventions, in which they reinforce a valued part of their identity, can effectively alleviate the harm of social identity threat. During a typical values-affirmation procedure, individuals are presented with a list of values, choose their top three values, and write about why these values are important to them (Steele, 1988; Sherman and Cohen, 2006; Cohen and Sherman, 2014). Values-affirmation interventions have been associated with positive outcomes across a variety of domains including improving health behaviors (Ehret et al., 2015; Ehret and Sherman, 2014) and promoting positive attitudes toward different groups (Badea and Sherman, 2019; Fien and Spencer, 1997).

Critical to this review, values-affirmation interventions are specifically efficacious at mitigating social identity threat among women in STEM settings. For example, having female students complete the values affirmation procedure prior to taking a challenging math test during a laboratory experiment protected them against the harmful effects of stereotype threat and enhanced their performance on a math test relative to students who did not complete the values affirmation (Martens, Johns, Greenberg, Shimel, 2006). Outside of the laboratory, compared to female students who did not receive the intervention, a values affirmation intervention increased female students' grades in a physics class from C to B range (Miyake et al., 2010). Moreover, these effects were strongest among female students who endorsed male STEM stereotypes and hence were most susceptible to experiencing social identity threat in that physics class. Another experiment with female engineering majors found that a values-affirmation intervention increased these students' grade-point averages and positive academic attitudes toward their major relative to students in a control condition (Walton et al., 2015). These findings suggest that values-affirmation interventions may help retain women in STEM majors and careers by encouraging positive attitudes toward STEM majors and success in STEM classes (i.e., higher grades). Values-affirmation interventions also can help protect women's self-esteem after witnessing an instance of sexism (Spencer-Rodgers et al., 2016), which may be pervasive in STEM classes (Steele et al., 2002). Although this intervention has been widely successful, encouraging women to focus on social values might be particularly helpful. When female students affirmed values related to social belonging and social bonds (as opposed to other values), they performed better on a math test (Shnabel, Purdie-Vaughns, Cook, Garcia and Cohen, 2013; see also Crocker et al., 2008).

Values-affirmation interventions also have positive effects for other negatively stereotyped groups in academia, which indicates that this intervention may be particularly helpful for women with multiple stereotyped identities in STEM. For instance, a values affirmation reduced the achievement gap between URMs and white students in an introduction to biology class (Jordt et al., 2017). In a large field study, researchers found that relative to students in a control comparison condition, URM middle school students who underwent the values-affirmation intervention had improved grades (Cohen et al., 2006), and these effects persisted for two years after the intervention (Cohen et al., 2009). Another field experiment across multiple time points demonstrated that compared to students who did not receive the intervention, black and Latinx high school students who completed a values-affirmation intervention showed increased academic performance (Sherman et al., 2013) and were more likely to enroll in college (Goyer et al., 2017).

Belongingness interventions. Given that values-affirmation interventions are most successful when women focus on their social belongingness values (Shnabel et al., 2013), it is unsurprising that interventions that promote feelings of belonging in threatening environments mitigate the harm associated with social identity threat. In particular, belonging interventions normalize concerns over not belonging or feeling welcome in an environment. During this intervention, students learn about others' experiences (typically at the same university and/or in the same major), and they discover that these students initially worried about never feeling welcome in the given environment, but eventually developed a sense of belonging. Importantly, these testimonials were written by students both with the same identity (i.e., women) and with different identities (i.e., men; Walton and Cohen, 2007), to help students recognize that everyone (not just those from their group) faces and ultimately overcomes challenges. Compared to students in a control condition that did not receive this intervention, this intervention improved female engineering major students' grades and resulted in their making more male friends in their major (i.e., becoming more integrated in the major; Walton et al., 2015). This belonging intervention has also enhanced a sense of belonging as well as academic performance among URMs and hence may be particularly effective for women with multiple stigmatized identities in STEM (Walton and Cohen, 2007; Walton and Cohen, 2011).

Interventions to Create More Inclusive Relationships and Group Settings

There are a variety of interventions that work to create more welcoming group environments (e.g., in classes and or at work) and improve mentor relationships for women in STEM. Similar to the strategies focused on changing personal attitudes and beliefs, these interventions aim to encourage equitable treatment of women, promote perceptions that STEM values feminine traits, and ultimately encourage the recruitment and retention of women in STEM. However, rather than influencing personal beliefs, these interventions focus on altering relationship and group dynamics.

Mentors and Sponsors

While scientists can act as role models and impact women's perceptions of STEM fields even when women lack direct contact with them, scientists only function as mentors when women have consistent interactions with them during which the scientists provide guidance and support (Gibson, 2004). Consequently, creating positive relationships is more important for mentoring than the previous described interventions, and encouraging these meaningful connections is critical to retaining women in STEM majors. Indeed, having mentors during college is one of the best predictors of women's reported involvement in their STEM major (Downing et al., 2005; Hernandez et al., 2017), and lacking mentors is one reason why women leave engineering majors (Marra, Rodgers, Shen and Bogue, 2009). Once women graduate from college, continuing to build mentor relationships is essential for the success of their career in STEM (Allen et al., 2004; Eby, et al., 2008).

Importance of mentorship. Mentors help women in academic science grow and thrive in their careers by connecting women with potential collaborators and supporting both research and teaching (Misra et al., 2017). Thus, positive mentor relationships help women advance in their STEM career—receive promotions and be successful in research and mentoring. Sponsor relationships are also useful interventions for advancing women in STEM. Differing from mentorship, sponsorship does not involve emotionally supportive relationships, but rather is focused on helping women excel in their careers by suggesting them for leadership positions and awards (Helms et al., 2016). Both male and female employees are more likely to report that they are advancing in their careers and feel more comfortable asking for raises when they have sponsors in their company (Hewlett et al., 2010). As a result of the benefits of sponsors, researchers have argued that connecting women to sponsors through formal programing is crucial for the advancement of women in STEM (Huston et al., 2019; Serbin, 2018). Sponsorship also might help address another factor hindering women from reaching top leadership roles in technology companies: their lack of visibility or opportunities to showcase their skills and value to the organization (Correll and Mackenzie, 2016). Specifically, sponsors can ensure that women have access to high-profile projects that can propel them into prestigious leadership positions.

Beyond just being supportive and providing career advice, mentors can help enhance female students' interest in STEM by providing valuable research opportunities in STEM laboratories. Research experiences in general encourage students (particularly those from underrepresented groups) to enter, persist, and advance (i.e., graduate) in STEM majors (Graham et al., 2013; Gregerman et al., 1998; Imafuku et al., 2015; Judge et al., 2010; Lim et al., 2015). For instance, Jones et al. explored how research experiences in biology impacted students who were interested in a biology major at the University of California, Davis. Compared to those who did not take part in research, those who participated in research persisted for longer in the biology major, were more likely to graduate with a biology degree, and earned higher grades in their biology courses (Jones et al., 2010). A qualitative study conducted at a primarily Hispanic-serving institution additionally found that students who were a part of affinity research groups in computer science reported that these groups help them grow as researchers and professionals, and promoted their integration into the larger computer science community (Villa et al., 2013). Importantly, these affinity research groups were strategically designed to create a sense of community in research labs via team-building activities, which suggests that labs should carefully construct inclusive and welcoming research opportunities to enhance interest in STEM.

In addition, research lab environments can be structured to counteract masculine stereotypes and demonstrate how STEM research can fulfill communal goals (Allen et al., 2018; Thoman et al., 2017). As one example relevant to recruitment, researchers surveyed a large sample of undergraduate research assistants across STEM laboratories and found that when a lab culture values using science to help others, URM research assistants expressed more interest and motivation in STEM (Thoman et al., 2017). Mentors therefore may play a vital role in ensuring the success of women in STEM; however, because of the pervasive masculine stereotypes in STEM, both male and female STEM faculty may be less interested in mentoring female students than male students (Moss-Racusin, et al., 2012). Therefore, it is important that interventions work to motivate scientists to act as mentors for women too. Video Intervention for Diversity in STEM, discussed above, is one such intervention that increases STEM faculty's intentions to mentor and work with female students (Moss-Racusin et al. 2018).

Mentor characteristics. Individuals have better mentor relationships when they feel similar to their mentors (Ensher and Murphy, 1997). For instance, when students across STEM majors believe their values match the values of their mentor, they indicate having more positive interactions with their mentors, which in turn predicts higher commitment to STEM careers (Hernandez et al., 2017). Thus, feeling similar to a mentor will help retain students in STEM majors and careers (Hernandez et al., 2017). Mentors who promote a growth mindset also help encourage academic success of women in STEM classes (Good et al., 2003). Specifically, mentors can promote a message of growth while providing critical feedback to their mentees, by emphasizing that they trust that the mentee can improve and reach their high expectations (Cohen et al., 1999; Yeager et al., 2014).

There is mixed evidence on the importance of having mentors with matching gender identities for women in STEM. Although Downing et al. (2005) found that having beneficial mentors increased persistence in STEM among women, they did not find that the gender of the mentor mattered: female and male mentors were equally effective. Other work has demonstrated that female students in STEM majors want female mentors, but do not have higher grade-point averages in their STEM classes with female mentors compared to male mentors (Blake-Beard et al., 2011). Providing contrasting evidence, an evaluation of a STEM summer research program found that female students gain more from their research experience (i.e., report gaining more skills and knowledge) when they had a female faculty mentor than a male faculty mentor (Morales et al., 2018).

A limitation of this previous research was that it examined naturally occurring mentor relationships and did not test whether mentors' gender mattered via a controlled experiment. To fill this gap, Dennehy and Dasgupta (2017) randomly assigned 150 female engineering students to work with a female or male peer mentor. They did not find differences in grade-point averages with the female versus male mentors, which was consistent with other past work (see Black-Beard et al., 2011). Nevertheless, the female mentor did increase female students' feelings of self-efficacy and belonging in engineering relative to the male mentor. Students with a female mentor also reported higher career aspirations in engineering, which suggests that belonging and self-efficacy may be more important than grade-point average for recruiting female engineering majors into STEM careers (Dennehy and Dasgupta, 2017). Although this experiment demonstrated the benefits of having a female peer mentor in engineering, it is important to note that having a mentor with only matching gender identity might not be as effective for women with multiple negatively stereotyped identities (Pietri et al., 2018c; Johnson et al., in press). Women of color, for example, may benefit from having a mentor with overlapping race or gender and race (Jackson et al., 1996). Thus, women with multiple stereotyped identities in STEM may thrive with a mentor matching their multiple intersecting identities, and this will be an important question to carefully test in future work.

Similar to the issues associated with female role models, requiring (the limited number of) women scientists to act as mentors for every female student creates additional service burdens for these scientists and may not be feasible. Therefore, interventions to help all faculty (including white cis-men) be supportive mentors for students from different backgrounds are critical for promoting diversity in STEM. To address this need, researchers have developed "culturally aware" mentor trainings, which begin by raising awareness of the structural biases in academia and then provide a set of tools and strategies to assist faculty in becoming culturally aware mentors (Pfund et al., 2013; Pfund et al., 2015). These trainings not only increased mentors' intentions to change their behaviors, but also enhanced positive mentor behaviors as reported by mentees (Pfund et al., 2015). By improving mentors' relationships with mentees, this training helped retain students in STEM majors and STEM graduate programs.

STEM Classes

Particularly relevant to recruiting women into STEM careers, STEM classes can be organized to promote the academic success of female students and encourage perceptions that STEM values communal goals. Although these classes can influence women's personal beliefs about STEM (Cheryan et al. 2011; Cheryan et al., 2013; Fuesting, et al., 2017), these interventions can also be implemented at higher levels by influencing instructors' relationships and interactions with students in the class and by changing the structure of these classes. Illuminating one such intervention, STEM classes can incorporate helping-focused projects to encourage beliefs that STEM fields value communal aims (Belanger et al., 2017). Both male and female students are more likely to believe that engineering classes with a service learning component (i.e., during which students use what they learn in class to help their local communities) fulfill communal goals and, in turn, are more interested in taking these classes (Belanger et al., 2017). Incorporating service learning projects in STEM classes, therefore, helps promote perceptions that STEM fields value communal goals and recruit women into STEM classes.

Reorganizing STEM courses to incorporate active learning exercises (e.g., having students work in groups, use clickers), generally improves learning among all students (Freeman et al., 2014; Handelsman et al., 2007) and is particularly beneficial for women in STEM. As one example, in a traditional lecture-based biochemistry class there was an achievement gap between male and female students, and incorporating active learning exercises alleviated this grade disparity (Gross et al., 2015). In another study, when female students took an introduction to computer science class with multiple group activities, they persisted longer in the computer science major than those who took a traditional lecture-based introductory course (Latulipe et al., 2018). Thus, ensuring that STEM courses integrate active learning is one strategy to help retain women in STEM majors. Active learning also decreases the achievement gap between URM students and white students in STEM introduction courses (Haak et al., 2011), which indicates that active learning may be especially helpful for women with multiple negatively stereotyped identities.

Integrating peer-led team learning (PLTL) in large STEM classes has the benefits of active learning and group activities as well as peer mentors (Dennehy and Dasgupta, 2017). In particular, during PLTL, students work in small groups to solve course-related problems, with the guidance of a peer mentor, a student who has previously been successful in the course. Incorporating PLTL improves learning outcomes generally in STEM classes (Streitwieser and Light, 2010; Wilson and Varma-Nelson, 2016) and is particularly beneficial for students from groups that have been underrepresented in STEM, including women and URMs (Horwitz et al., 2009; Thiry and Hug, 2012). For example, when PLTL was implemented in introductory STEM courses at one institution, it improved the completion rate of the entire group of students and specifically enhanced Latinx students' completion rate (Gates et al., 2016; Thiry and Hug, 2012). Providing additional evidence, across eight universities, Horwitz et al. (2009) found that relative to female students who took a traditional lecture-based introduction to programming course, those who took this class with PLTL were more likely to enter, persist, and earn higher grades in computer science majors. PLTL also may encourage students to participate in helpful research experiences. In particular, Gates et al. (2015) examined the effectiveness of PLTL across primarily Hispanic serving institutions in introductory computer science classes and found that PLTL not only improved students' problem-solving skills, but also increased the likelihood of students assisting with computer science research (Gates et al., 2015).

Aside from the pedagogical benefits of active learning, working together on a task (via active learning exercises) can promote social connection with other students, engagement with the task, and belonging in the STEM environment (Carr and Walton, 2014). The benefits of working in groups on STEM tasks has also been demonstrated with young children, where children who worked in a group (rather than alone) on a STEM task showed higher engagement and interest in the task (Master et al., 2017; Master and Walton, 2013), demonstrating that interventions to recruit women into STEM majors and careers can (and should) be implemented early in the educational system. Indeed, one large-scale strategy to spark girls' interest in STEM disciplines where they are least represented (e.g., computer science, physics, engineering) is ensuring that girls are exposed to classes dispelling masculine STEM stereotypes in the fields early in their educational development (Cheryan et al., 2017).

STEM instructor characteristics. Changing the structure of STEM classes requires the involvement and commitment of STEM instructors, and some may not feel comfortable or know how to incorporate active learning in their courses. To address this issue, STEM education researchers have developed successful training and workshops that can teach instructors about these classroom techniques. The National Academies Summer Institute for Undergraduate Education is a successful week-long workshop during which STEM instructors learn how to develop and effectively incorporate active learning into their courses (Pfund et al., 2009). Moreover, bias literacy interventions have been successfully incorporated into these summer institutes (Moss-Racusin et al., 2016). The workshop involved the presentation of empirical evidence regarding gender bias in an effort to resonate with these science faculty, and it communicated that increasing diversity in science is part of everyone's responsibility. Two weeks after the intervention, faculty participants demonstrated not only increased awareness of gender bias and the importance of diversity in science, but also a greater approach orientation toward diversity. In other words, they were more inclined to engage proactively in positive diversity behaviors and were less likely to engage in avoidant behavior (Moss-Racusin et al., 2016). Multiple-day workshops for STEM educators have the ability to not only increase active learning, but also decrease harmful gender biases, and these trainings can thus help recruit and retain women in STEM majors (Moss-Racusin et al., 2016; Pfund et al., 2009).

Instructors' connections with students are also a critical predictor of whether women will feel welcome and be successful in STEM classes. Students generally are more engaged in active learning and earn higher grades in STEM classes when they trust their instructor (i.e., believe their instructor cares about and accepts them) (Cavanagh et al., 2018). Even though encouraging trust and good relationships with students promotes engagement, it is important that STEM faculty still work to challenge students. Compared to those with a growth mindset, math instructors with a fixed mindset are more likely to employ comfort strategies (e.g., assigning less work) for students with low math ability (Rattan et al., 2012). Comforting rather challenging students leads students to believe that their instructors have low expectations for the students' success in math and harms their math motivation (Rattan et al., 2012).

A recent large-scale study further demonstrated the benefits of instructors with growth mindsets, examining the performance of students across 634 STEM courses (Canning et al., 2019). Those who took classes with an instructor with a growth mindset—versus fixed—were more likely to believe that the instructor emphasized learning and development, were more motivated to their best work, and, importantly, earned higher grades. Moreover, in classes with fixed mindset instructors the achievement gap between white and URM students was twice as large than in classes with growth mindset instructors (Canning et al., 2019). Across another series of studies, research found that when students believed that their STEM instructors had a growth mindset, they were more likely to believe that STEM environments afford communal goals, which ultimately relates to higher interest in STEM majors and careers (Fuesting et al., 2019). Finally, instructors with a growth mindset are more likely to adopt active learning exercises in their courses (Aragón et al., 2018), and growth mindset interventions are less effective in classes when teachers have a fixed mindset (Schmidt et al., 2015). Taken together, multiple studies suggest that training STEM instructors to have a growth mindset will improve the performance of all students (not just women), and specifically will help recruit female students from STEM classes into STEM majors and careers.

Group Compositions

The group composition of classes or small activity groups in class (for female students), and working groups (for female scientists) may also play an important role in recruiting and retaining women in STEM. For instance, female students performed worse on a math test when they were in a setting with a majority of male students than when there was a majority of female students (Inzlicht and Ben-Zeev, 2000). In another study, female students anticipated less belonging and were less interested in attending a conference that had a majority of male students versus gender parity (Murphy, et al., 2007). Women established in STEM also anticipated less belonging and were less interested in an academic conference when most of the attendees were men (Richman et al., 2011), and women working in STEM environments where they are outnumbered by men experience the highest level of gender identity threat compared to men and to women who are not outnumbered by men (Van Veelen et al., in press).

As discussed, women may benefit generally from active learning, and being in female majority activity groups may create the most welcoming and inspiring STEM classroom environments (Springer et al., 1999). For instance, female students were more likely to participate and feel less anxious in female majority groups compared to male majority groups in an engineering class. The female students in the female majority groups also indicated higher STEM career aspirations and confidence (Dasgupta et al., 2015). Beyond gender, related work has demonstrated that URMs in STEM also benefit from environments with other URM students (Gates et al., 2011; Hurtado et al., 2007; Johnson et al., 2019).

When it is not possible to have female majority groups, it may be helpful to address the biases of the male students in STEM classes. Female and URM STEM majors report facing unwelcoming environments in their STEM class from fellow students (Hurtado et al., 2007; Robnett, 2016; Steele et al., 2002). Particularly relevant to group activities, Meadows and Sekaquaptewa (2013) found that when male students were working in groups in engineering courses, they tended to take on active roles (e.g., talk more, present group work), whereas women tended to be in technical roles (e.g., note takers). Thus, bias literacy interventions may not only be beneficial when implemented among STEM faculty, but may also promote more inclusive STEM classroom environments when targeted toward students (Becker and Swim, 2011; Becker and Swim, 2012; Kilmartin et al., 2015). As one example of the benefits of bias literacy interventions in classrooms, in an experiment by Bennett and Sekaquaptewa (2014), introductions to engineering courses were randomly assigned such that some students heard a presentation on the importance of egalitarian social norms (i.e., intervention classes) or did not hear this presentation (i.e., control classes). Relative to those in the control classes, white male students who heard the presentation reported valuing diversity more and having higher intentions to speak out against discrimination (Bennett and Sekaquaptewa, 2014). Another successful intervention for students employed videos to demonstrate equitable classroom interactions (Lewis et al., in press). Specifically, researchers assigned STEM majors to watch a video of mixed-gender groups conforming to gender stereotypes (i.e., male students speaking more than female students) or acting in non-stereotypical ways (i.e., female students talking more male students). The STEM majors then completed a group task, modeled after typical STEM classroom activities. In the interventions group, female and male students spoke equal amounts, whereas in the non-intervention teams, male students spoke more than female students, as revealed from both self-reported data and video footage of group interactions (Lewis et al., in press).

Outside of the classroom, bias literacy interventions can help create more equitable working groups and committees. For instance, when search committees took part in the interactive theater GEAR-UP workshop (described above), these committees had more positive group dynamics, and members engaged in more equitable behaviors (Shea et al., 2019). Bias literacy trainings targeted toward managers of working teams at tech companies also encourage equitable treatment of female employees (Correll, 2017). Specifically, what Correll (2017) describes as a “small wins approach” begins by teaching managers about gender bias in technology and continues by identifying unequitable treatment in the managers’ teams. This approach then works with managers to create small changes to address the unfair treatment. Although these modifications may be small, they are nevertheless helpful for promoting equity and inspiring managers to continue altering their behavior and their teams’ culture (Correll, 2017).

Research Opportunities

Lastly, more students (particularly those from underrepresented groups) enroll, persist, and advance (i.e., graduate) in STEM majors when they take part in research experiences (Graham et al., 2013; Gregerman et al., 1998; Imafuku et al., 2015; Judge et al., 2010; Lim et al., 2015). For instance, Jones et al. explored how research experiences in biology impacted students who were interested in a biology major at the University of California, Davis. Students who participated in research persisted for longer in the biology major, were more likely to graduate with a biology degree, and earned higher grades in their biology courses (Jones et al., 2010). A qualitative study conducted at a primarily Hispanic-serving institution additionally found that students who were a part of affinity research groups in computer science reported that these groups helped them grow as researchers and professionals, and promoted their integration into the larger computer science community (Villa et al., 2013). Importantly, these affinity research groups were strategically designed to create a sense of community in research labs via team-building activities, which suggests that labs should carefully construct inclusive and welcoming research opportunities to enhance interest in STEM. STEM faculty can also design their classes to provide students with research opportunities to ensure that all students have beneficial experiences with STEM research (Hatfull et al., 2006; Lin et al., 2015; Russell et al., 2007).

In a related vein, research lab environments can be structured to counteract masculine stereotypes and demonstrate how STEM research can fulfill communal goals (Allen et al., 2018; Thoman et al., 2017). As one example relevant to recruitment, researchers surveyed a large sample of undergraduate research assistants across STEM laboratories and found that when a lab culture values using science to help others, URM research assistants expressed more interest and motivation in STEM (Thoman et al., 2017).

Interventions at the Organization and Policy Level

Although the overwhelming majority of social science interventions in the extant literature have focused on individual-level and relational or group-level approaches to reducing biases that impede women's advancement in STEM and to changing the masculine culture of STEM to make it a more welcoming environment for women, there is oftentimes little personal incentive to engage in the best practices that research has revealed. The most successful personal strategies for reducing one's own biases, for example, necessitate more than a one-off educational exposure for their success to be maintained in the long term (Lai et al., 2014). Rather, once individuals step out of the context where the bias intervention took place, they must practice regulating their biases and continue battling the omnipresent masculine stereotypes associated with STEM that lead to those biases in the first place (Burns et al. Parker, 2017).

Without top-down organizational, institutional, and policy-level approaches, many individuals simply are not sufficiently internally motivated to put in the work necessary to maintain the benefits of micro-level interventions over time, assuming they self-select into these interventions in the first place when they are made available to them. Indeed, people vary in their motivation to control their prejudices (Plant and Devine, 1998; Dunton and Fazio, 1997), with some individuals actually being motivated to express prejudice (Forscher et al., 2015). To complicate matters, many people who have never been introduced to the concept of implicit biases may be simply unaware that they are contributing to a negative climate for women in STEM, and, as a result, may not realize that they should take part in bias literacy interventions and trainings (Monteith, 1993; Monteith and Voils, 1998; Perry et al., 2015). Perhaps even more frustrating, some people may have the personal awareness and motivation to try to engage in more pro-diversity, inclusive behaviors (e.g., restructuring a course to include more active learning activities that have known benefits for women), but find that such actions—which often require greater investment of time and effort than status quo behaviors—are not rewarded in their organizations. As one example, even when STEM professors are motivated to add more active learning in their classes, or to attend workshops on how to become better educators, they are often not rewarded or are even harmed in promotion for such actions (Yoder, 2018). When organizations and policies do not provide top-down incentive to attend to personal bias and contribute actively to a more welcoming and inclusive environment, many people will fail to recognize their potential for having and acting on biases or feel as though such initiatives are counterproductive to their individual success.

Organizations and policy makers, therefore, can serve several important roles to encourage people to be more proactive partners in improving conditions for women in STEM and to set the tone of the environment formally in ways that make women feel more welcome. First, organizations can enact policy mandating diversity education and training to reduce bias and discrimination among all of its members. In this way, they can ensure that the individual-level interventions described earlier in this review are made available to the entire organization rather than just to interested persons. Additionally, organizations can take systematic steps to reduce the impact of bias and discrimination on women and other stigmatized targets at all points of contact with the organization (e.g., recruitment, selection, advancement). Finally, gender-inclusive policies within organizations and institutions can be put in place to create a more systemic positive climate for women. Importantly, these policies often not only benefit the targets they are designed to serve, but also benefit members of the organization more broadly (Smith et al., 2018). Key to the success of these strategies is organizational responsibility; that is, organizations must have clear plans in place and designate members of the organization as supervisors to ensure that those plans are implemented (Kalev et al., 2006).

Reducing Bias and Discrimination

Earlier in this review, we described numerous effective interventions for reducing individual biases that often translate into both subtle and overt forms of discrimination. However, when the organization's position on diversity and inclusion—and more specifically the prohibition of bias and discrimination—is weak, these interventions are unlikely to be maximally beneficial. By definition, formal discrimination is that involving access and opportunity (Hebl et al., 2002), including educational opportunities, hiring, performance evaluation, compensation, and promotion. Indeed, federal, state, and local laws prohibit formal discrimination of members of protected classes, and consequently, such egregious forms of discrimination are less prevalent when those laws and policies are enforced (e.g., Barron and Hebl, 2013). For example, in the United States, affirmative action policies mandated by Executive Order no. 11246 increased employment for women and racial minorities among organizations subject to affirmative action in the 15 years immediately following its signing (Leonard, 1984). Such data underscore the importance of policy and legislation in curbing more overt forms of discrimination and harassment.

Interpersonal discrimination is impossible to legislate per se, as its intent is less clear than that of formal discrimination. Interpersonal discrimination can be defined as interpersonally rude verbal or non-verbal behavior directed at stigmatized targets (Hebl et al., 2002), including prejudicial remarks couched in humor and interpersonally cold behavior. Research suggests that here too, a strong organizational position against bias and discrimination is critical. Specifically, Cortina (2008) theorized that in organizations with weak norms regarding bias, individuals' implicit biases will translate into uncivil behavior and an overall unwelcoming climate for diversity. Indeed, in such environments, incivility tends to be selective, targeting women and other underrepresented minorities more than members of highly represented groups (Cortina et al., 2013). However, in environments in which formal policies are in place, we not only see decreases in formal discrimination but also in interpersonal discrimination. For example, in communities where there are laws prohibiting formal discrimination, researchers have found that customer service representatives are also more likely to demonstrate more positive interpersonal behavior toward members of stigmatized groups (Barron and Hebl, 2013). Collectively, these studies strongly suggest that for any bias reduction interventions to have significant impact in an organization or institution, there must be support from the top down. Indeed, that argument dates at least as far back as Allport (1954) and is supported in the STEM context specifically. For example, a comprehensive review of 19 National Science Foundation ADVANCE-funded institutional transformation efforts found that internal organizational factors such as senior administrative support and involvement were strong predictors of success in effecting organizational change (Bilimoria et al., 2008; Bilimoria and Liang, 2011).

Diversity training and education. Organizations should mandate that individuals reduce their biases through diversity training and education. In addition to all of the aforementioned successful bias reduction interventions—largely conducted individually and via laboratory experiments—several large-scale studies demonstrate the wider-reaching impact that diversity training can have within organizations and institutions. For example, during a four-year intervention at the University of New Hampshire the National Science Foundation ADVANCE-funded theater-based workshop GEAR-UP, designed to teach faculty about implicit gender bias, saw an increase in women recruited into STEM and promoted to full professor during the period of the intervention (Shea et al., 2019). These correlational data provide reason for optimism that increasing faculty awareness of gender bias through creative and engaging diversity education programs can improve the recruitment and advancement of women in STEM. Of course, randomized controlled experiments offer more rigorous tests of the diversity training hypothesis. One successful example is the ADVANCE-funded effort described in some detail earlier: the Women in Science and Engineering Leadership Institute at the University of Wisconsin – Madison. Above and beyond its success in raising individual participants' awareness of and knowledge about gender bias in STEMM, a randomized controlled experiment to test the success of the program demonstrated that it increased the proportion of women hired in departments in the experimental condition and more broadly changed the climate in those departments in which a critical mass of faculty participated. Specifically, this gender bias habit-breaking intervention increased the proportion of women STEMM faculty hired by 18 percentage points, whereas the proportion hired in departments in the control condition remained stable over time (Devine et al., 2017). Additionally, Carnes et al. (2015) found that in treatment group departments in which 25 percent or more faculty attended the 2.5-hour gender bias habit-breaking intervention, faculty reported more gender equity–promoting behaviors even three months later, which has implications for the retention of women in STEM. This intervention demonstrates the power of a short evidence-based training to have highly scalable impact. Not only did it improve the recruitment of women faculty, but also, to the extent that all participating faculty continued to work actively toward achieving diversity goals through positive, gender-inclusive behavior, it successfully changed the climate for women in their classrooms, labs, and departments. Regrettably, few such large-scale gender bias reduction initiatives have been as rigorously tested in the STEM context, underscoring the need for more randomized controlled experiments in this domain (also see Moss-Racusin et al., 2014).

Increased representation. Besides educating people about and training away biases, some organization-level interventions have additionally focused on increasing the representation of women and other underrepresented group members in key decision-making roles in order to reduce the likelihood that discrimination will occur in important decisions (e.g., employment). Interestingly, there is mixed evidence regarding the success of this strategy. On one hand, some studies have found significant benefits of increased representation. For example, Nittrouer et al. (2018) found that the presence of women either as sole deciders or as members of committees responsible for inviting colloquium speakers to top-50 research-focused departments of social and life sciences significantly increased the likelihood that women would be invited. Such findings have important implications for advancement, given the weight of prestigious invited talks in promotion and tenure decisions. Other studies, however, have not yielded the expected positive outcomes. For example, using data collected over a six-year period, Glass and Minnotte (2010) found that having more women on search committees did not increase the likelihood of having more women finalists or of actually hiring women. Similarly, in a study of STEM department chairs and their performance indicators, having more women faculty in a department and/or having a female department chair did not predict the adoption of more gender-inclusive initiatives that would serve to improve climate and retention rates (Su et al., 2015). Thus, representation alone does not seem to mitigate the problem of gender bias and discrimination.

Indeed, many studies have demonstrated that gender biases and stereotypic perceptions of women's competence in STEM and research-focused careers are widely held by both men and women (Madera et al., 2009; Moss-Racusin et al., 2012). Likewise, with regard to race, many black Americans implicitly favor whites, and to the extent that they do, they are less likely to select in-group members as partners on tasks relying on stereotypically "white" competencies (Ashburn-Nardo and Johnson, 2008; Ashburn-Nardo et al., 2003). Consequently, although increased representation is an important goal and certainly does not exacerbate gender (and racial) disparities in STEM, it does not guarantee a discrimination-free environment. Bias reduction training among *all* members of an organization is therefore critical, and only top-down incentives and organizational policies can ensure that such training takes place. It is important to keep in mind, however, that prejudice-reduction effects, especially on implicit biases, are small, and the most effective are more time-intensive, labor-intensive, and costly than many organizations may be willing to invest (Lai et al., 2014). Furthermore, a systematic review of various diversity management strategies implemented in more than 700 private sector organizations demonstrated that bias reduction efforts overall were the least effective strategy for increasing the numbers of women and URMs recruited into management positions (Kalev et al., 2006). As such, this review underscores the need for a multi-pronged approach to maximize the success of interventions.

Minimizing the Impact of Biases on Targets

Recognizing that bias reduction strategies take significant time and resources to implement, many organizations additionally or alternatively create and implement policies and procedures to minimize the negative impact of biases on stigmatized targets. Two approaches comprise the bulk of the extant literature: accountability structures that curb the application of biases in decision-making processes, and programs designed to offer support to targets of discrimination (Kalev and Green, 2007).

Accountability structures. The use of accountability structures suggests that organizational leadership understands that biases are widely held but that they are less likely to be applied under certain circumstances. These structures are largely derived from social science tests of dual process models (e.g., Fazio, 1990) that demonstrate that many individuals are personally motivated to avoid acting on biases that are often automatically activated but are often unable to recruit the cognitive resources necessary to control their application. This may be especially true in many professional contexts where individuals have many simultaneous demands on their attention and are therefore distracted, hurried, and less likely to process information carefully and thoughtfully.

One such accountability structure that could help to reduce gender disparities in STEM with regard to recruitment and advancement is blind review of student and employee applications and promotion materials (see Dasgupta and Stout, 2014) and blind initial review of grant applications (see Raymond and Goodman, 2019). For example, research reveals that blind auditions for orchestra positions increased the number of female musicians hired (Goldin and Rouse, 2000). Experimental evidence has shown that identical lab manager applications attributed randomly to a man versus a woman produced biased results favoring men among the very faculty who would review such applications in their everyday jobs (Moss-Racusin et al., 2012); finding ways to de-identify materials as much as possible therefore seems sensible. Indeed, an investigation of the impact of journals' adopting a double-blind review policy demonstrated a significant increase in the number of female first-authored papers (Budden et al., 2008), which are a critical factor in women's academic career advancement.

Other accountability structures have also demonstrated success in the recruitment and selection process. For example, increasing the diversity of the applicant pool leads to more equitable hiring decisions overall (Chang and Cikara, 2018; Heilman, 1980). During the selection process, whether members of the organization have an inclusion versus an exclusion mindset during the review is also important in reducing the likelihood of stereotypic judgment. More specifically, thinking of one's task as identifying suitable applicants for a position rather than as eliminating unsuitable candidates reduces stereotypical decision making in selection (Hugenberg et al., 2006). Such decision making is enhanced by the presence of a formally trained search advocate on search committees. Indeed, one institution saw a doubling of its women faculty in the College of Engineering when search advocates were employed (Shaw et al., 2019).

Another accountability structure that has received a lot of empirical attention, especially in the industrial/organizational psychology literature, is the structured interview. Tests of aversive racism theory have repeatedly demonstrated that when applicant credentials are mixed, reviewers are more likely to make biased decisions that disadvantage stigmatized targets in the recruitment and selection process (e.g., Dovidio and Gaertner, 2000). In reality, credentials are likely mixed more often than not; the varied experiences of applicants for educational and work opportunities make it difficult to identify the single most qualified individual. To further stack the deck against women and other targets of bias, research on confirmatory hypothesis testing reveals that when interviews lack formal structure, interviewers will ask interviewees questions in such ways that elicit expected responses based on group membership (Snyder and Cantor, 1979; Snyder and Swann, 1978). For example, if interviewers expect men to exhibit more agency and authority in the workplace, they will be more likely to ask questions of men than of women that will afford greater opportunities to highlight their competencies in this domain.

The classic and influential findings from the literature on aversive racism theory and confirmatory hypothesis testing led industrial/organizational psychologists to explore the benefits of structured interviews in recruitment and selection. Interviews can be structured in a variety of ways, including basing questions on findings of job analyses in an effort to focus on relevant job knowledge, skills, and abilities; asking identical questions of every interviewee; minimizing follow-up questions and prompts; and reserving interviewee questions until the end of the formal interview (Campion et al., 1997). These structures are designed to reduce the variability of experience from one interview to the next and to keep the focus on relevant questions rather than questions that lead to ingroup favoritism and preference for similar candidates as the interviewer. Indeed, meta-analyses of interview data demonstrate that although disparities due to applicant race and gender in interview outcomes are widespread, structured interviews at least decrease their magnitude (e.g., Huffcutt and Roth, 1998). Beyond the more widely studied effects of their impact on outcomes for women and racial minorities, structured interviews have been shown to decrease biased outcomes for pregnant (Bragger et al., 2002) and overweight (Kutcher and Bragger, 2004) interviewees.

It is important further to secure faculty buy-in for engaging in these evidence-based hiring practices, especially given the role of faculty on search committees. Toward that end, one large-scale survey demonstrated a significant relationship between direct and indirect exposure to a faculty recruitment workshop and support for gender-equitable hiring practices. Faculty who attended a recruitment workshop, or who were in a department with colleagues who had, expressed increased support for and intentions to engage in equitable hiring practices (Sekaquaptewa et al., 2019).

Support programs. Another organization-level strategy for reducing the impact of biases on women and other underrepresented group members in STEM is providing them with support programs to buffer them from the ill effects associated with the experience of discrimination. Mentoring and networking programs for women have perhaps received the most empirical attention of all organizational strategies. For instance, because women are more likely than men to feel isolated and a lack of belonging in STEM departments (NRC, 2009) and to report inadequate mentorship (Rosser, 2004), Dasgupta and Stout (2014) recommended that STEM departments incentivize mentoring activities, structured professional development opportunities at key points throughout the career, and continued funding of ADVANCE and related programs to foster retention. Indeed, at the relationship level, having positive connections has been identified as a successful intervention for both female students (Dennehy and Dasgupta) and female STEM faculty (Mirsa et al., 2017).

Mentoring and networking organization-level programs for women in STEM appear to have a variety of benefits. Many of these benefits are related to the social and emotional support that women experience as a result of their participation in the programs (Thomas et al., 2015), but some programs also demonstrate more career-related benefits, including an increased sense of career agency and more gender-inclusive initiatives (e.g., improved parental leave policy) on their campuses (O’Meara and Stromquist, 2015), as well as increases in publications and promotions (e.g., Files et al., 2008). In other words, these practices potentially benefit not only the retention of women in STEM but also their advancement.

Some data regarding mentoring and networking, however, indicate some challenges and downsides to such programs. For example, in Thomas et al.'s (2015) qualitative analysis of the outcomes of ADVANCE-funded peer mentoring circles among STEM faculty at a research-intensive university, faculty reported mixed perceptions. Some faculty valued the support and reported that it met specific, important instrumental needs regarding how to succeed (e.g., finding an answer to a specific question), but others expressed discomfort providing support to others. Such findings point to some serious unintended consequences of support programs for women and other underrepresented groups when implemented at the level of an organization. First, these programs imply that women and other targets are less capable than others of navigating their careers and understanding what it takes to be successful. Furthermore, the programs often add extra burden on targets of discrimination to "fix themselves." Indeed, some women report feeling resentful of the pressure to support other women and perceive that their involvement was not the best use of their time (Thomas et al., 2015). Given data that demonstrate that women do most of the academic "housekeeping" or low-reward service (Guarino and Borden, 2017), such perceptions should not be surprising. This finding points to the need to combine large-scale mentoring programs, with trainings to teach men how to act as effective mentors for women in STEM (see Pfund et al., 2015).

In summary, despite growing out of good intentions to minimize the impact of bias and discrimination on women in STEM, these strategies do not, by themselves, address the underlying problems regarding the STEM culture in which many women feel unwelcome. Indeed, the organizational strategies described thus far—designed to reduce bias and limit its impact—are considered traditional diversity management strategies, which are important for reducing the likelihood of formal, overt forms of discrimination involving personnel decisions, but are arguably less effective in promoting inclusion and making organizations a welcoming place for women and other underrepresented groups (Kalev and Green, 2007).

Changing the Organizational Climate and Culture

Above and beyond more traditional diversity management strategies, Kalev and Green (2007) argued that organizations need to increase inclusion to improve the organizational climate for women and other underrepresented minorities, thereby increasing the likelihood of their retention and advancement. Increasing gender inclusivity requires the recognition that all members of the organization must work together truly to reap the many benefits that having diverse perspectives offers. One way to think about this is to consider how to make those interactions more positive, such that everyone feels welcomed and valued. Toward that end, we find Nishii's (2013) gender inclusion framework most helpful, as it suggests that the successful promotion of inclusion in the workplace may parallel Allport's (1954) seminal conditions necessary to improve intergroup attitudes through contact. That is, in a gender-inclusive environment, men and women (and all their various intersectional identities) must have equal status and value within the organization, espouse common goals to solve shared problems, and cooperate with each other (especially in ways that promote their friendship potential). Furthermore, consistent with our earlier arguments, the support of authorities must be evident.

Nishii (2013) suggests that the intergroup contact conditions translate into an inclusive environment in several key ways, as reflected in her measurement scale of perceived inclusion. First, despite social hierarchies that exist in society, organizations can engage in equitable (employment) practices to ensure that all members of the organization have approximately equal status within that environment. For example, recognizing that women are asked to perform non-promotable service tasks more than men (Babcock et al., 2017), some academic institutions are taking steps to create gender parity in service loads by using online dashboards where everyone in the unit can see each other's current obligations. A randomized experiment recently demonstrated that implementing the dashboard practice increased fairness perceptions across faculty and that women and faculty of color were more likely to advocate for themselves when the evidence of their workload was available to everyone (O'Meara et al., 2018). Other equitable practices include the organization's commitment to and investment in diverse representation at all levels of the organization, fair and equitable performance reviews and compensation, flexible benefits that meet diverse needs of members of the organization, and mechanisms through which individuals can voice concerns and grievances safely and without fear of reprisal (see Buchanan et al., 2014, for safe reporting recommendations).

Second, Nishii (2013) suggests that inclusive organizations strive for the integration of differences. More specifically, they should actively promote the valuing of and respect for difference, recognize the humanity and individuality of all members of the organization such that they are free to be their authentic selves, and respect and encourage work-life balance. For example, academic institutions could stop tenure clocks for caregiving, offer paid leave for family emergencies broadly defined, and fund on-campus childcare facilities (Dasgupta and

Stout, 2014). Professional societies could reduce fees for membership and conference registration to help women and men ease back into work following time away for family reasons (Dasgupta and Stout, 2014). Such policies speak primarily to Allport's (1954) cooperation condition of positive intergroup contact. By ensuring that people see others within their organization as valued individuals rather than cogs in the wheel, there is greater potential for friendship and more personalized interactions whereby people feel supported to do their best work.

It is important to note, however, that mere "feel good" work-life policies are not sufficient to change STEM organizations' overall masculine and highly competitive culture. Smidt et al. (2017) note that the current "business model" of universities around the world, with a focus on performance outcomes and growth, has led to formal mechanisms (e.g., points system, pressure to get top national rankings) and informal mechanisms (e.g., peer pressure) that yield poorer outcomes for women. Such mechanisms normalize unrealistic work hours and faculty's putting career over other obligations. In their research, women who were granted family leave time experienced decreased research activity and career setbacks. They reported feeling forced to choose between being a "good mother" or a "successful academic" which led to "gendered guilt." Moreover, formal evaluation systems (merit, promotion and tenure) still penalized those academics who took advantage of flexible work arrangements for failing to be research-productive. "Flexible" policies in their view meant that everyone works from home, all day.

Third, Nishii (2013) discusses the importance of inclusion in decision making within the organization. Said differently: voice. Indeed, the importance of voice cannot be overstated. In one study of academic women in the natural sciences, those who reported having voice in their department were buffered from the effects of having a negative workplace climate on their job satisfaction (Settles et al., 2007). The organization can help individuals have voice by creating a climate for healthy debate and discussion and by valuing each member's input. Additionally, organizations can empower their members to make their own decisions autonomously and encourage their feedback to implement new and/or revise ineffective or unequitable work practices. In such environments, members of the organization can have and work toward common goals, consistent with one of Allport's conditions for successful intergroup contact (1954).

Taken together, this research underscores the need to have multiple policies simultaneously in place to create the most welcoming environments. Yet surprisingly few studies have examined the impact of having more gender-inclusive policies on workplace outcomes for women in STEM specifically, at least in ways that are scientifically rigorous. Described here are a couple of recent exceptions that offer support for taking a multi-pronged approach, not just via traditional diversity management approaches, but also per Nishii's (2013) framework of gender-inclusive workplace cultures. Importantly, both examples demonstrate that having policies that benefit women do not come at the expense of their male colleagues and often actually increase their benefits as well.

First, Hall et al.(2018) found consistent support across three studies (including an experiment) for a model in which organizations that have more gender-inclusive policies significantly decreased social identity threat among women in STEM, which is key for their retention. Consistent with the argument that having diverse representation is insufficient for reducing perceived threat (Kalev and Green, 2007), an internal meta-analysis of their findings demonstrated that perceived representation was less important for women's identity-safety than the presence of gender-inclusive policies. Their findings further revealed that the effect of policies on social identity threat was mediated by perceptions of conversation quality between men and women. Specifically, to the extent that organizations promoted gender-inclusivity, cross-gender conversations were perceived to be more positive, which in turn predicted lower perceptions of threat. In short, Hall et al. (2018) found that bringing more women into a male-dominated environment (in this case, engineering) will not work without the organization's demonstrated commitment to creating a positive, inclusive workplace climate and culture in which women feel valued and accepted by their male coworkers.

Another example of a rigorously tested multi-pronged approach to improving conditions for women in STEM was reported by Smith et al. (2018) and Smith et al. (2015). Their National Science Foundation ADVANCE-funded Project TRACS (Transformation through Relatedness Autonomy and Competence Support) initiatives are based on the tenets of self-determination theory (Deci and Ryan, 2012). Specifically, self-determination theory posits that people have universal needs for relatedness (having meaningful social connections), autonomy (having perceived control over processes and outcomes), and competence (feeling a sense of mastery and self-efficacy over one's environment). Toward those ends, Project TRACS included three major initiatives. First, by hiring dedicated staff to provide grant support for faculty—with priority given to women faculty—the project aimed to enhance research capacity and opportunity to increase the likelihood of women's advancement. A second initiative was geared toward enhancing work-life balance through the addition of a dedicated family advocate for faculty. The family advocate's primary responsibilities included addressing inquiries pertaining to caregiving and leave policies and supporting resources such as campus childcare. Lastly, an initiative with the goal of enhancing cultural attunement delivered education and training for search committees regarding implicit biases and created equity advocates positions to promote fairness and inclusion. These interventions resulted in searches in which women candidates were 6.3 times more likely to receive an offer and 5.8 times more likely to accept offers they received (Smith et al., 2015). TRACS was successful not only with respect to recruitment but also in terms of retention. Smith et al. (2018) collected data longitudinally over a three-year period and found that all faculty who engaged in some way with these initiatives (men and women, STEM and non-STEM) experienced benefits. Specifically, the more they took part in TRACS, the greater their self-reported autonomy, competence, and relatedness, which in turn predicted increased job satisfaction, a key driver of retention.

Conclusions

This review highlights many successful individual-level interventions that have been rigorously tested both in the laboratory as well as in large-scale field experiments. This past work demonstrates multiple efficacious techniques to reduce personal biases against women in STEM, to mitigate misconceptions that STEM fields are masculine disciplines with nerdy scientists or fields that require brilliance for success, and to alleviate the harmful influence of social identity threat in STEM environments. Although additional research should continue to explore how these interventions impact women with intersecting identities and examine how male allies can support women in STEM, the numerous individual-level interventions are a promising sign for future gender parity in STEM. Moreover, there is also a fairly large of body of research emphasizing effective strategies for creating beneficial instructor and mentor relationships, and encouraging belonging, engagement, and comprehension in STEM classes. One issue with individual-level and group/relational-level interventions, however, is these strategies may not be transformative without organizational and policy-level support.

Indeed, as Allport (1954) theorized, policy and top-down reinforcement is necessary to effect positive change. If members of an organization do not perceive the support by authorities for diversity and inclusion initiatives, there is little incentive for a culture shift and, in all likelihood, there will be cultural inertia and reinforcement of the status quo. For instance, STEM faculty may lack motivation to restructure their courses if such changes are not valued in promotion and tenure (Yoder, 2018). As a result, organizations must change reward structures in ways that incentivize doing the hard work of diversity and inclusion. Although traditional diversity management approaches are important, such as reducing individual biases through diversity training and education and offering supportive programs to buffer women and other underrepresented groups from the harmful consequences of discrimination, they only go so far in creating feelings of inclusion within the organization (Kalev and Green, 2007). If organizations are only checking boxes by increasing representation, offering voluntary diversity training, or hosting an occasional women's networking event, they are not doing nearly enough to change their culture. A multi-pronged approach is necessary to generate impactful change.

Taken together, this review demonstrates that there are far fewer scientifically rigorous tests of organization-level interventions than there are of interventions at the individual, relational, or group level. This is likely due in part to pragmatics, as it is less challenging to assign individual participants randomly to micro-level interventions than to investigate factors experimentally at the macro level. That said, given the multitude of individual-level interventions with demonstrated success in changing biases and enhancing women's sense of belonging and efficacy, it is surprising that few of them appear to be implemented on a large scale. We hope that this review will assist organizations and policy makers in recognizing that laboratory-based individual-level experiments can be just as translational and applicable as scaled-up field studies. Indeed, there have been multiple reviews suggesting that organizations implement interventions and best practices established from individual-level experiments (Walton, 2014; Walton et al., 2015; Walton and Wilson, 2018).

TABLE 1 Interventions Across Levels

Intervention	Level	Goal	Outcome(s)	Tested in STEMM Field?	Citation
Bias literacy (Video Interventions for Diversity in STEM)	Individual level (behavioral intentions)	Recruitment	Reported behavioral intentions to recruit and mentor female students	Yes: faculty across science departments	Moss-Racusin et al., 2018
Bias literacy workshop (faculty recruitment workshop)	Individual level (attitudes and behavioral intentions)	Recruitment	Positive attitudes toward equitable search strategies from workshop attendees, intentions to use equitable strategies during search	Not specifically: faculty across all departments	Sekaquaptewa et al., 2019
Changing STEM classroom environments	Individual level (changing students' individual beliefs about computer science)	Recruitment	Reported interest in computer science	Yes: computer science	Cheryan et al., 2009; Cheryan 2011
Describing male or female STEM mentor (using communal words in ads)	Individual level (interest in working with a STEM mentor)	Recruitment	Reported interest in working with STEM mentor	Yes: across STEM majors	Fuesting and Diekman, 2016
Describing STEM jobs with communal of feminine words	Individual level (interest in working at job)	Recruitment	Reported interest at working at jobs	No: female students generally (not specifically STEM majors)	Gaucher et al., 2011

Describing biomedical research as fulfilling communal or helping goals	Individual level (career motivation)	Recruitment	Reported motivation to pursue a career in biomedical sciences	No: male and female students generally (not specifically STEM majors)	Brown et al., 2015
Having a female scientist describe career as fulfilling communal goals (helping others working with others)	Individual level (interest in STEM)	Recruitment	Reported interest in STEM careers	No: female students generally (college students and adolescent girls)	Diekman et al., 2011 (with college students) Weisgram and Bigler, 2006 (with college students)
Presenting students with female scientist role models	Individual level (career motivation)	Recruitment/ retention	Reported intentions to pursue a career in engineering	Yes: female college engineering majors	Stout et al., 2011
Writing about favorite role models	Individual level (sense of fit in STEM)	Recruitment	Reported sense of fit in the sciences	No: female middle school students attending a science summer camp	O'Brien et al., 2017
Having a black female or male scientist in recruitment materials (e.g., on a school or company's website)	Individual level (anticipated belonging)	Recruitment	Anticipated belonging at company or school	Yes: black women across STEM majors	Johnson et al., 2019; Pietri et al., 2018

Encouraging women scientists in television shows	Individual level	Recruitment	Majoring in STEM and entering a STEM career (participants respectively reported whether they watched the X-files with Agent Scully)	Yes: women currently working in STEM fields	Geena Davis Institute on Gender in Media, 2018 (see also Steinke)
Having a STEM graduate program emphasis that men and women work hard for success in the program	Individual level (reported interest)	Recruitment	Reported interest in graduate program	Yes: female students generally, and female STEM graduate students	Smith et al., 2012
Teaching female students that intelligence is malleable and can improve	Individual level (career motivation, grades in math)	Recruitment	Higher career motivations in math, higher grades in math	No: female middle school students	Blackwell et al., 2007; Good et al., 2003
Bias literacy workshop (Women in Science and Engineering Leadership Institute)	Individual-level behavior	Retention	Self-reported actions to promote equity in department (when at least 25% of department attended)	Yes: departments in medicine, science, and engineering	Carnes et al., 2015
Ensuring black female students have black women as role models	Individual level (reported belonging)	Retention	Reported sense of belonging in STEM	Yes: black female students across STEM majors	Johnson et al., 2019

Having multiple allies for women in a STEM environment	Individual level (reported belonging)	Retention	Reported sense of belonging in STEM	Yes: black female STEM majors	Johnson et al., 2019
Values affirmation: having women write about a valued aspect of their identity	Individual level (grades and attitudes toward major)	Retention	Higher grades and positive attitudes toward engineering major, higher grades in a physics class	Yes: female engineering majors and female students enrolled in a physics class	Miyake et al., 2010; Walton et al., 2015
Exposing students to counter-stereotypical exemplars (female leaders)	Individual-level beliefs	Advancement	Women-leadership IAT	No (student samples)	Dasgupta and Asgari, 2004
Instructing students to imagine contact (imagining a strong capable leader)	Individual-level beliefs	Advancement	Women-strength IAT	No (student samples)	Blair et al., 2001
Bias literacy workshop	Individual-level beliefs	Advancement	Women-leadership IAT	Yes: medicine faculty	Girod et al., 2016
Bias literacy training (incorporated into week-long workshop on improving STEM education)	Relational/group levels (STEM instructors' beliefs about STEM courses)	Recruitment	Reported valuing of diversity in STEM classes	Yes: STEM instructors across fields	Moss-Racusin et al., 2016
Bias literacy workshop (interactive	Group-level behavior (search committees)	Recruitment	Search committees engaged in positive behavior	Yes: across all departments, with a focus on STEM	Shea et al., 2019

theater GEAR UP workshop)					
Lab environments that promote perceptions that STEM is communal	Relational/group level (research mentors and lab environments)	Recruitment	Reported interest and career motivation in STEM	Yes: male and female research assistants across STEM laboratories	Allen et al., 2018; Thoman et al., 2017
STEM instructors with a growth mindset	Relational/group level (STEM instructors and STEM classes)	Recruitment	Interest in STEM career, motivation in classes, and higher grades in STEM courses	Yes: male and female students in STEM classes	Canning et al., 2019; Fuesting et al., 2019; Ratton et al., 2012
Incorporating service-learning projects into STEM courses	Group level (structuring STEM classes)	Recruitment	Interest in taking a STEM course	No: male and female college students' interest in taking an engineering class	Belanger et al., 2017
Peer-led team learning in introductions to computer science courses	Relationship/group level (structuring STEM classes)	Recruitment/ retention	Entering and persisting in computer science major, higher grades in computer science courses	Yes: female students in computer science	Horwitz et al., 2009
Providing a female mentor	Relational (having female peer mentors)	Recruitment/ retention	Reported belonging and self-efficacy, and interest in engineering career	Yes: female engineering majors	Dennehy and Dasgupta, 2017

Egalitarian norms	Group level (STEM classes)	Recruitment/ retention	Higher valuing of diversity and intentions to confront bias	Yes: white male students in introductory engineering course	Bennett and Sekaquaptewa, 2014
Fostering positive mentor relationships for female college students	Relational level (importance of mentor relationships)	Retention	Remaining in engineering majors or reported interest in major	Yes: female engineering majors and female STEM majors generally	Downing et al., 2005; Marra et al., 2009
Culturally aware mentor training	Relational (improving mentoring relationships)	Retention	Reported improved mentoring behaviors	Yes: clinical and translational researchers	Pfund et al., 2013; Pfund et al., 2015
Integrating active learning in STEM courses	Relationship/group level (structuring STEM classes)	Retention	Persistance in computer science major	Yes: female computer science majors	Latulipe et al., 2018
Having female majority activity groups in STEM classes	Relationship/group level (group composition)	Retention	Higher reported interest in STEM careers	Yes: female engineering majors	Dasgupta et al., 2015
Having students watch a video of students behaving counter-stereotypically in project teams	Relationship/group level (student group intervention	Retention	Resulted in women and men contributing equal amounts in group work (rather than men speaking more than women)	Yes: students in STEM project teams	Lewis et al., in press
Research experiences in college	Relationship/group level (research mentors)	Retention/ advancement	Persistance in biology major, graduating with biology degree, and	Yes: male and female students who reported	Jones et al., 2010

			earning higher grades in biology major	an interest in majoring in biology	
Encouraging mentor relationships for STEM female faculty	Relational level (positive mentor relationships)	Advancement	Helping build connections with regard to research and teaching (i.e., aspects of the job that help with promotion)	Yes: female faculty across the sciences	Mirsa et al., 2017
Sponsors promoting women for leadership positions and prestigious awards	Relationship/group (sponsor relationships)	Advancement	More advancement opportunities	No: but multiple review papers suggest sponsorship should be utilized in STEM	Hewitt et al., 2010 (see also Huston et al., 2019; Serbin, 2018).
Bias literacy workshop (Women in Science and Engineering Leadership Institute)	Organization level (hiring)	Recruitment	Increased hiring of women in STEMM departments by 18%	Yes: departments in medicine, science, and engineering	Devine et al., 2017
Bias literacy workshop (faculty recruitment workshop)	Organization level (norms)	Recruitment	Positive attitudes toward equitable search strategies among department mentors who did not attend workshop (when a higher percentage of departmental faculty attended)	No: faculty across all departments	Sekaquaptewa, et al., 2019

Bias literacy workshop (interactive theater GEAR UP workshop)	Organization level (hiring)	Recruitment	Percentage of women hired in STEM departments went from 40% to 63.6%	Across all departments, with a focus on STEM	Shea et al., 2019
TRACS training for faculty search committees (relied on self-determination theory)	Organization level (hiring)	Recruitment	Searches in intervention were 6.3 times more likely to make an offer to a woman, and women were 5.8 times more likely to accept	Yes: across STEM departments	Smith et al., 2015
Bias literacy workshop (Women in Science and Engineering Leadership Institute)	Organization level (climate)	Retention	Fit perceptions in department, comfort in raising personal/ professional conflict in department	Yes: departments in medicine, science, and engineering	Carnes et al., 2015
Gender-inclusive policies	Organization level (climate)	Retention	More positive cross-gender conversations and lower social identity threat	Yes: working engineers	Hall et al., 2018
Dedicated grant support staff, family advocate, equity advocates (Project TRACS)	Organization level (climate)	Retention	Increased autonomy, competence, relatedness, and job satisfaction	Yes: STEM and non-STEM faculty	Smith et al., 2018

TRACS grant-writing boot camp	Organization level (climate)	Retention/ advancement	Higher likelihood of submitting and receiving a grant	Yes: female STEM faculty	Smith et al., 2017

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