

# Psychology of Popular Media

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# Using Comics and Tweets to Raise Awareness About Gender Biases in STEM

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Brief messages on social media have the potential to raise awareness about gender biases in science, technology, engineering, and mathematics (STEM) by reducing defensive reactions. A preregistered study with 436 college students examined the effect of reading tweets with comics versus text-only tweets about gender biases in STEM on perceptions about women in STEM. Participants completed a set of questionnaires before and after seeing a series of comics or text-only tweets. Women, but not men, felt less defensive regarding their views about women in STEM after viewing either type of post. In addition, after reading either type of post, participants viewed the climate for women in STEM as less positive. Finally, women in the comic condition thought that there were more women in STEM after reading the comics, but men's perceptions did not change in either condition. Thus, the results provide preliminary evidence that comics about women in STEM may be effective at changing women's perceptions about women in STEM. In addition, the text-only tweets were equally effective as the comics for decreasing women's defensiveness and altering views about the climate for women in STEM.


## Public Policy Relevance Statement


Brief messages, such as comics or tweets (Twitter messages) about gender bias in science can raise awareness of the challenges faced by women scientists. However, these messages were more likely to improve perceptions of women in STEM for women readers than for men.

**Keywords:** gender biases, STEM, comics, tweets, defensiveness


Comics and webcomics have become an important form of media that can both entertain and educate. For example, the popular webcomic *xkcd*, which has hundreds of thousands of visitors per day, is about math, science, and technology (Cohen, 2008). Similarly, comics have been an important medium for spreading information about health, both in formal education environments as well as in public health campaigns (Krakow, 2017; Leung et al., 2017; Montgomery et al., 2012).


However, an open question is whether comics are a useful medium for raising awareness about social issues, such as the prevalence and harm of gender biases against women in science, technology, engineering, and math (STEM). This question is particularly timely, given the recent effort by a group of earth scientists to collect stories about gender biases in STEM and disseminate those stories as web comics (Bocher et al., 2020).


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 The data are available at [https://osf.io/dhjng/?view\\_only=29a2796f062840289f1389463251e0ba](https://osf.io/dhjng/?view_only=29a2796f062840289f1389463251e0ba)

 The experiment materials are available at [https://osf.io/87http/?view\\_only=b4bd5acd19e34edcb2c83446c8c2df65](https://osf.io/87http/?view_only=b4bd5acd19e34edcb2c83446c8c2df65)

 The preregistered design is accessible at [https://osf.io/aypfs/?view\\_only=3ae110a6fd074da2a2c35c733050c636](https://osf.io/aypfs/?view_only=3ae110a6fd074da2a2c35c733050c636)

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## Gender Bias in STEM

Women in STEM fields face pervasive biases regarding their abilities (Nguyen & Ryan, 2008; Shapiro & Williams, 2012), which can cause them to leave those fields (Beasley & Fischer, 2012). For example, studies have shown that individuals are more likely to hire men than women for jobs in STEM fields, even when the candidates have equivalent qualifications and prior performance (Moss-Racusin et al., 2012; Reuben et al., 2014; Steinpreis et al., 1999). Similarly, in studies of undergraduate STEM students, participants attributed men's failures in STEM tasks to external factors, whereas women's failures were attributed to internal causes (LaCosse et al., 2016). These problems are particularly evident in areas that are traditionally considered more masculine, such as computer science, engineering, and physics (Cheryan et al., 2017).

Recognizing that these challenges exist is a key first step toward improving the climate for women in STEM. For example, members of scientific research committees with implicit gender biases who were skeptical about the prevalence of the effect of biases were less likely to promote women scientists than those who were more aware of the effects of biases (Régner et al., 2019). Importantly, men, compared to women, tend to see gender biases against women as less impactful and less likely to negatively influence women (Freedman et al., 2018). Furthermore, when shown gender bias research, men are more likely to evaluate that research negatively (Handley et al., 2015).

Therefore, a key question is how to raise awareness, particularly among men, about the bias women face without increasing defensiveness against that idea. Previous research has shown that narratives can be an effective way of raising awareness of gender bias in STEM (Pietri et al., 2017). For example, Pietri et al. (2017) created a set of 5-min narrative videos using entertaining scenarios to demonstrate gender bias. These videos increased immersion and raised awareness of bias. In their study, nonnarrative expert interview videos also increased awareness. We expand upon this idea in the present research by considering how narratives can be adapted into shorter messages that can effectively teach people about gender biases without engendering defensiveness.

## Narratives

A narrative can be defined as a communication that includes characters, temporality, and causality: Narratives describe a cause and effect sequence of events that happens over time to a particular individual or individuals (Dahlstrom, 2014). Narratives can be an effective way of increasing empathy toward groups who have experienced discrimination (Johnson et al., 2013; Mazzocco et al., 2010). In part, narratives may be effective because they can evoke feelings of immersion or transportation into a narrative world, which can increase persuasion (Green & Brock, 2000). Individuals may become transported into even very brief stories, such as advertisements (Escalas, 2004).

Previous research suggests that people can become transported into both text and visual media (e.g., films or comics), but comparisons across media are rare. Visual media may be more engaging for people with lower motivation (Green et al., 2008). Thus, it is possible that narratives that include visual imagery might make it easier to become transported. Furthermore, previous work has

suggested that familiarity with the topics or settings of a story can increase transportation (Green, 2004). Transportation can be effective for both men and women, but for the current topic, it is possible that women may become more transported because of their likely greater familiarity with gender bias.

Our study extends the work on narratives by using shorter messages in different media: comics and tweets. In some cases, the messages in comics or short tweets can be considered very short narratives, showing the experience of a person (e.g., a girl being turned away from a math competition because an adult thinks "she must be in the wrong room"). Comics may be a particularly effective medium for raising awareness, as people may be more responsive to humor if the message is perceived as threatening (Conway & Dubé, 2002; Mukherjee & Dubé, 2012; Nabi, 2016).

## Education Through Comics

Comics are a useful educational tool, as they combine illustration with written text, allowing readers to gain a better understanding of the concept than they would with just text (Carney & Levin, 2002; Mayer & Gallini, 1990). The effects of comics on increased understanding and better recall have been shown in both applied settings such as health care (Delp & Jones, 1996) and educational settings such as biology classes (Hosler & Boomer, 2011). For example, emergency room patients who were given wound care instructions that included cartoon illustrations were more compliant with the instructions than patients who did not see cartoons (Delp & Jones, 1996).

In addition to increasing understanding of content matter, comics can also help shift attitudes and behavioral intentions related to social issues. For instance, a comic book about the human papillomavirus vaccine increased positive attitudes toward the vaccine among parents (Katz et al., 2014). Similarly, adult participants who viewed a brochure with a comic reported greater intentions to engage in behaviors related to wind energy, compared to those who saw a brochure with photographs (Rodriguez & Lin, 2016).

Many existing studies, such as the ones described earlier, have examined longer form comics (including comic books, pamphlets, or cartoons). However, short-form comics, which contain only a single panel or a few panels of illustration, may also be effective at addressing social issues.

## Tweets as Persuasive Tools

Comics may provide special benefits, but messages conveyed in text-only tweets may also have the potential to influence social issues. Advocacy, health, and political organizations use tweets to support their causes (Lovejoy et al., 2012; Park et al., 2016), and Twitter is also used for science communication more generally (Su et al., 2017). Although there is some evidence for the persuasive efficacy of Twitter use (Kruikemeier, 2014), tweets are not always effective (Boerman & Kruikemeier, 2016). Furthermore, tweets can also be used for negative social influence, such as by spreading stereotypes and increasing prejudice (Thornton, 2013). In general, the mechanisms and boundary conditions for the influence of tweets remain to be explored, especially for sensitive topics such as bias or stereotypes.

### Emotional Responses

Whether the narratives are traditional, long-form stories or presented via short messages in comics or tweets, transported readers can experience strong emotions, which can lead to attitude change. On the one hand, posts raising awareness of bias may create negative emotions; viewers may be angry or frustrated that such bias exists. Negative emotions and motivations might provide an impetus to try to work for social change, but it is also important to make sure that messages highlighting bias do not create a sense of discouragement or futility among women (Pietri et al., 2019).

On the other hand, such posts could create positive emotions. People may be able to laugh at the situation through the author or artist's portrayal of it. They may also feel empowered because other people have overcome similar experiences (e.g., a sense of solidarity), or happy that others are speaking out about these issues. Social media can be a source of social support (DeAndrea et al., 2012) and empowerment (Leong et al., 2019). We suggest that because of the potentially stronger narrative connection that they create, comics may be especially likely to lead to these positive emotions.

### Sharing

A further benefit of using short messages is that they can be easily shared on social media, potentially increasing their reach. In addition to being easily sharable because they fit within the space constraints of popular social media platforms, comics or narrative tweets can also evoke positive emotion and arousal, which may make them more likely to be shared (Berger & Milkman, 2012). Furthermore, comics may appear more novel than text-only messages, increasing the likelihood of sharing (Cappella et al., 2015). In general, images may draw reader attention (Sargent, 2007), and recent eye-tracking studies show that positive images in social media posts attract higher visual attention, which leads to greater sharing intentions (Keib et al., 2018).

### Reducing Defensiveness

Because most people view themselves as egalitarian, they may also respond to bias-related messages with reactance or defensiveness (Howell et al., 2017). Defensive reactions can include downplaying or dismissing the information or derogating the individual who has communicated the message (e.g., describing someone who attributes a failure to discrimination as a "complainer"; Kaiser & Miller, 2001). Defensiveness can be an obstacle to attitude change because audiences may reject messages about bias to protect their self-image. For the issue of gender bias, although it is more likely that men might be defensive about recognizing bias, it is also possible that women might not want to recognize systemic bias or sexism, perhaps to protect their own identity or position or to maintain a belief in a just world (Derks et al., 2016).

Addressing sensitive issues such as gender bias through brief observations or narratives may be a way to reduce the defensiveness that more direct discussions of bias can evoke for some audiences. The comics (and tweets) that we used in the current study were illustrations of the ways that bias still exists in STEM fields, but presented in a way that does not directly threaten viewers or readers (e.g., does not confront them with their own biased

thoughts or behaviors). This approach follows current recommended practices of avoiding assigning blame to participants for current diversity issues (Moss-Racusin et al., 2014).

Although our comics presented observations rather than jokes per se, audiences likely associate a comic panel with humor, and this association may help increase acceptance of the message. Humorous media content has been shown to deepen audiences' processing and may shift attitudes more than serious content in the long term (Nabi et al., 2007). In addition, humor can create a buffer and decrease readers' defensiveness when they are confronted with an uncomfortable topic (Conway & Dubé, 2002) and alleviate some of the negative emotional responses caused by negative messages (Mukherjee & Dubé, 2012; Nabi, 2016). However, it is important to note that humor can also backfire. For example, humorous memes based on a racial stereotype increase perceived acceptability of the stereotype in individuals prone to stereotyping (Duchscherer & Dovidio, 2016).

Here, we measured defensiveness indirectly by examining participants' derogation of the concerns of women in science, and as a secondary measure, derogation of the message creator (the comic artist). Specifically, we measured participants' agreement with statements that women in science complained too much or overreacted to how they were treated. We also examined whether men and women react differently to a comic artist who is portraying a message related to gender bias.

### Perceptions of STEM Professions

Although the primary focus of our messages was on raising awareness of bias, such posts may also help combat stereotypes, such as increasing the recognition that women are also chemists, engineers, and mathematicians. Indeed, such posts may raise awareness of gender issues more generally, so that people are less likely to make gender-stereotypic judgments (e.g., may be less likely to assume that a nurse is a woman.)

### Differences by Audience Gender

Not surprisingly, previous research suggests that men and women may react differently to messages about gender bias, such that women have a greater recognition of such bias (Freedman et al., 2018; Moss-Racusin et al., 2015) and men are more skeptical about gender bias research (Handley et al., 2015). In addition, previous research suggests that similarity between a character and an audience member can lead to greater transportation into narratives (Green, 2004). We expect that gender effects may emerge here, such that women will show greater responsiveness to the messages overall (less defensiveness, greater transportation, and more emotional response) and may also be more positive toward the message creator (e.g., may have a more positive attitude about the comic artist). However, for the reasons described earlier, comics may be especially effective at creating change for resistant audiences. Thus, the effectiveness of comics may be particularly evident among men because they may be more likely to be resistant to the message at the start.

## Overview and Hypotheses

In sum, short comics may provide a variety of advantages for persuasion about women in STEM: They may reduce defensiveness through humor, promote sharing, and provide transportation into a very brief narrative. Although tweets about individuals' experiences share some of these characteristics, they may be less effective because they lack the visual element. Therefore, in the present study, we tested the effect of reading comics versus text-only tweets about gender biases in STEM on attitudes toward women in STEM and the biases they might face. The main hypotheses are presented in Table 1.

The study design, analyses, and hypotheses were preregistered prior to data collection at the Open Science Framework. The pre-registration, data, and materials can be found at [https://osf.io/aypfs/?view\\_only=43c08ce0e3c5485db7d3faffe2c4895](https://osf.io/aypfs/?view_only=43c08ce0e3c5485db7d3faffe2c4895).

## Method

### Participants

A power analysis conducted in G\*Power with 95% power for a  $2 \times 2 \times 2$  mixed analysis of variance (ANOVA), with an effect size of  $d = .2$ ,  $\alpha = .05$ , four groups, and two time points indicated a sample size of 436 participants. To account for attrition, 463 college students fluent in English from the United States and the United Kingdom were recruited on Prolific Academic, a participant crowdsourcing website. Of the 463 participants, there were 172 men and 264 women, four participants reported "other" for gender, and 23 participants did not report gender. As described in the preregistration plan, we excluded participants who indicated "other" for gender or did not report gender, leaving an analytic sample of 436 participants ( $M_{\text{age}} = 25.59$ ,  $SD = 7.62$ ; 4.1% African American/Black, 5.7% Asian/Asian American/British Asian, 1.8% Hispanic/Latino, 3.4% multiracial, 75.7% White, and 9.2% responded with another category, mostly with "British").

### Procedure

Participants were randomly assigned to either the Comic condition or the Text condition. In both conditions, participants first completed a set of pretest questionnaires. Next, participants either saw a set of 12 tweeted comics or 12 tweeted statements. In both cases, five of the 12 tweets were related to gender biases (Figures 1 and 2). For example, the tweet version of one bias statement read, "At Jamie's school today. Saw Mathletes coach turn 2 girls away—told them babysitting training was down the hall. #mathletes." The comic version illustrated these events. The other seven tweets were unrelated to gender biases and were used as filler items. After each tweet, participants indicated how they felt about the tweet on a five-item smiley face scale. This pictorial scale was used to mimic social media interactions. Then participants completed the posttest measures.

### Measures

#### Awareness of Climate for Women in STEM

Participants were asked about the likelihood that a woman in STEM would have positive experiences (feel comfortable, succeed, be happy in her career, be supported by other women in her classes/workplace, be supported by men in her classes/workplace, take on a leadership role, have her ideas supported by others, get credit for her

work, be respected by authority figures in her classes/workplace) and negative experiences (experience instances of bias because of her gender, be treated unfairly because of her gender, be discriminated against because of her gender) on a 1 (*very unlikely*) to 7 (*very likely*) scale. The responses to the negative experience items were reversed scored, and all of the items were averaged into a scale for analyses (pretest Cronbach's  $\alpha = .87$ ; posttest  $\alpha = .90$ ).

#### Transportation

To assess transportation, a modified version of the Transportation Short Form (Appel et al., 2015) was used. Participants indicated on a 1 (*not at all*) to 7 (*very much*) scale how true each of the following was for them: I could picture myself in the scenes of the events described in the tweets; I was mentally involved in the tweets while reading them; the tweets affected me emotionally; while reading the tweets I had a vivid image of the situations described ( $\alpha = .79$ ).

#### Emotional Responses

Participants indicated how they were feeling after reading the tweets on a 1 (*strongly disagree*) to 7 (*strongly agree*) scale for a set of emotions. Three composite scores were created: negative emotions (angry, depressed, frustrated:  $\alpha = .80$ ), motivated emotions (empowered, motivated to take action<sup>1</sup>,  $\alpha = .69$ ), and amusement (happy, amused:  $\alpha = .71$ ).

#### Willingness to Share

Participants were asked to indicate how likely they would be to share the tweet/comic in some way (over e-mail, social media, in person) after each comic or tweet on a 1 (*extremely unlikely to share*) to 5 (*extremely likely to share*) scale. A composite score of willingness to share was created by averaging the ratings for each person for the gender-related comics or tweets (comics  $\alpha = .82$ ; text only tweet  $\alpha = .81$ ).

#### Defensiveness

**Derogation of Women in STEM.** To assess defensiveness to issues regarding gender biases in STEM, participants were asked for their agreement on a 1 (*strongly disagree*) to 7 (*strongly agree*) scale to the following items: women in STEM overreact about how they are treated; women in STEM complain too much about how they are treated; women in STEM are right to be upset about how they are treated (reverse-scored); women in STEM should pay more attention to their science and less attention to how they are treated (pretest  $\alpha = .88$ ; posttest  $\alpha = .90$ ).

**Comic Artist Perceptions.** Furthermore, participants in the Comic condition indicated their agreement with the following four items on a 1 (*strongly disagree*) to 7 (*strongly agree*) scale: The comic artist is a complainer (reverse-scored); the comic artist is perceptive; the comic artist is talented; the comic artist is incompetent (reverse-scored). The items were averaged into a composite score ( $\alpha = .72$ ).

#### Perceived Gender Distribution of Professions

To measure perceived percentages of women in STEM, participants were asked what percent of engineers are men, what percent

<sup>1</sup> The item "discouraged from trying" was originally intended to be in the motivation composite, but it was not associated with the other two items (composite with all three items:  $\alpha = .10$ ).



**Table 1**  
*Main Hypotheses*

Category	Hypothesis
Awareness of climate for women in STEM	Hypothesis 1: Comics will be more effective than text-only tweets at conveying awareness of gender bias in STEM (e.g., lowering the perception of the climate for women in STEM) compared to tweets.
Transportation	Hypothesis 2: Women will be more aware of bias than men. Hypothesis 3: Comics will be more transporting than tweets.
Emotions	Hypothesis 4: Women will be more transported than men. Hypothesis 5: Participants in the comic condition will report less negative emotion than participants in the text only tweet condition. Hypothesis 6: Women will report higher levels of empowerment than men, particularly in the Comic condition.
Willingness to share	Hypothesis 7: Women will be more likely to share than men.
Derogation of women in STEM	Hypothesis 8: Participants will be more likely to share comics than tweets. Hypothesis 9: Comics will be more effective than text-only tweets at decreasing derogation of women in STEM compared to tweets. Hypothesis 10: Women will engage in less derogation of women in STEM than men.
Comic artist perceptions STEM professions	Hypothesis 11: Men's derogation of women in STEM will decrease in response to comics, but not tweets. Hypothesis 12: Women will feel more positively about the comic artist than men. Hypothesis 13: After reading the messages, individuals will hold less stereotypic views of the gender distributions across professions (e.g., will report higher percentages of women chemists and engineers). Hypothesis 14: Comics will have a stronger effect than tweets on decreasing stereotypic views of the gender distributions

*Note.* STEM = science, technology, engineering, and mathematics.

of nurses are men, and what percent of chemists are women (see Materials on OSF for filler items).

## Results

A results summary and ANOVA statistics for the primary hypothesis tests are presented in Table 2.

### Awareness of Climate for Women in STEM

A 2 (Gender: Man, Woman)  $\times$  2 (Condition: Tweet, Comic)  $\times$  2 (Time: Time 1, Time 2) mixed ANOVA on perceptions about climate in STEM for women found that participants viewed the climate for women in STEM as less positive at Time 2 ( $M = 4.51$ ,  $SD = .98$ ) than at Time 1 ( $M = 4.67$ ,  $SD = .86$ ), ( $F(1, 431) = 51.51$ ,  $p < .001$ ,  $\eta_p^2 = .11$ ). Thus, the tweets and comics were effective at shifting perceptions. Contrary to our expectations (Hypothesis 1), there was no main effect of condition (Table 2). As predicted (Hypothesis 2), there was a significant main effect of gender such that men saw the climate for women in STEM as more positive ( $M = 4.71$ ,  $SD = 1.46$ ) than women ( $M = 4.52$ ,  $SD = 1.25$ ). There were no significant interactions: all  $p > .12$ .

### Transportation

Contrary to predictions (Hypothesis 3), a 2 (Condition)  $\times$  2 (Gender) between-subjects ANOVA on transportation found that participants in the Tweet condition ( $M = 4.00$ ,  $SD = 1.29$ ) were more transported than participants in the Comic condition ( $M = 3.77$ ,  $SD = 1.36$ ). However, as predicted (Hypothesis 4), men were less transported ( $M = 3.71$ ,  $SD = 1.29$ ) than women ( $M = 4.00$ ,  $SD = 1.35$ ).

### Emotions

A 2 (Condition)  $\times$  2 (Gender) between-subjects ANOVA on negative emotions (frustrated, angry, depressed) found that men reported

fewer negative emotions after seeing both comics and tweets ( $M = 3.14$ ,  $SD = 1.40$ ) than women ( $M = 3.54$ ,  $SD = 1.33$ ), ( $F(1, 432) = 8.84$ ,  $p = .003$ ,  $\eta_p^2 = .02$ ). Contrary to hypotheses (Hypothesis 5), there was no main effect of condition (see Table 2) or interaction between condition and Gender ( $F(1, 432) = 1.41$ ,  $p = .236$ ,  $\eta_p^2 < .01$ ).

A 2 (Condition)  $\times$  2 (Gender) between-subjects ANOVA on motivation emotions (empowered, motivated to take action) found the hypothesized (Hypothesis 6) main effect of gender but not the expected interaction of gender and condition (Table 2). Women were more likely to report feeling empowered ( $M = 3.56$ ,  $SD = 1.28$ ) than men ( $M = 3.05$ ,  $SD = 1.40$ ). There was no main effect of condition ( $F(1, 432) = .08$ ,  $p = .782$ ,  $\eta_p^2 < .01$ ).

### Exploratory Analysis of Positive Emotions

An exploratory 2 (Condition)  $\times$  2 (Gender) between-subjects ANOVA on positive emotions (happy, amused) found that participants in the text-only tweet condition reported more positive emotions ( $M = 4.04$ ,  $SD = 1.21$ ) than participants in the comic condition ( $M = 3.81$ ,  $SD = 1.30$ ), ( $F(1, 432) = 4.59$ ,  $p = .033$ ,  $\eta_p^2 = .01$ ). There was no effect of gender, ( $F(1, 432) = 2.41$ ,  $p = .122$ ,  $\eta_p^2 = .01$ ), or interaction between condition and gender, ( $F(1, 432) = 1.88$ ,  $p = .171$ ,  $\eta_p^2 < .01$ ).

### Willingness to Share

A 2 (Condition)  $\times$  2 (Gender) between-subjects ANOVA on willingness to share the tweets/comics related to bias found, as predicted (Hypothesis 7), that women were more willing to share what they saw ( $M = 2.74$ ,  $SD = .10$ ) than men ( $M = 2.28$ ,  $SD = .97$ ). Contrary to hypotheses (Hypothesis 8), there was no main effect of condition. The interaction of gender and condition was not significant: ( $F(1, 432) = .30$ ,  $p = .584$ ,  $\eta_p^2 < .01$ ).

### Derogation of Women in STEM

Contrary to hypotheses (Hypothesis 9), a 2 (Gender)  $\times$  2 (Condition)  $\times$  2 (Time) mixed ANOVA on derogation of women in

**Figure 1**  
*Comic Tweets About Gender Biases*



*Note.* Comics by N. Kane, Copyright 2018 by Mary Flanagan. Reprinted with permission. See the online article for the color version of this figure.

STEM found that participants in the Tweets condition engaged in less derogation ( $M = 2.70$ ,  $SD = 1.87$ ) than participants in the Comics condition ( $M = 2.98$ ,  $SD = 1.87$ ). As predicted (Hypothesis

10), men engaged in more derogation ( $M = 3.15$ ,  $SD = 2.06$ ) than women ( $M = 2.54$ ,  $SD = 1.68$ ). Participants derogated STEM women more at time 1 ( $M = 2.83$ ,  $SD = 1.32$ ) than at Time 2

**Figure 2**  
Text-Only Tweets About Gender Biases



*Note.* Tweets by Tiltfactor, Copyright 2018 by Mary Flanagan. Reprinted with permission. See the online article for the color version of this figure.

( $M = 2.73$ ,  $SD = 1.41$ ),  $F(1, 427) = 8.23$ ,  $p = .004$ ,  $\eta_p^2 = .02$ . The main effects were qualified by a significant interaction between gender and time,  $F(1, 427) = 4.64$ ,  $p = .032$ ,  $\eta_p^2 = .01$ . Contrary to hypotheses (Hypothesis 11), posthoc analyses showed that men did not change in their level of derogation between Time 1 ( $M = 3.16$ ,  $SD = 1.34$ ) and Time 2 ( $M = 3.14$ ,  $SD = 1.45$ ), but women's derogation decreased from time 1 ( $M = 2.61$ ,  $SD = 1.27$ ) to time 2 ( $M = 2.46$ ,  $SD = 1.32$ ;  $M_{\text{difference}} = .14$ ,  $SE = .04$ ,  $p < .001$ ). There were no other significant interactions: all  $p > .20$ .

### Comic Artist Perceptions

An independent samples  $t$  test on perceptions of the comic artists showed that, as predicted (Hypothesis 12), women felt more positively about the comic artist ( $M = 5.02$ ,  $SD = 1.02$ ) than men.

### Perceived Gender Distribution of Professions

Contrary to hypotheses (Hypothesis 13), a 2 (Gender)  $\times$  2 (Condition)  $\times$  2 (Time) mixed ANOVA on percent of chemists

that participants thought were women found no main effect of time. However, there was a significant interaction of gender, condition, and time. Posthoc analyses showed that in the Tweet condition, there was no difference in perceived percentage of female chemists among men between Time 1 ( $M = 38.37$ ,  $SD = 15.38$ ) and Time 2 ( $M = 38.10$ ,  $SD = 16.18$ ;  $M_{\text{difference}} = .27$ ,  $SE = 1.11$ ,  $p = .809$ ) or among women between Time 1 ( $M = 43.29$ ,  $SD = 14.79$ ) and Time 2 ( $M = 41.83$ ,  $SD = 16.42$ ;  $M_{\text{difference}} = -1.46$ ,  $SE = .89$ ,  $p = .103$ ). In the Comic condition, there was also no significant difference among men between Time 1 ( $M = 42.67$ ,  $SD = 17.17$ ) and Time 2 ( $M = 40.78$ ,  $SD = 19.08$ ;  $M_{\text{difference}} = -1.90$ ,  $SE = 1.24$ ,  $p = .127$ ). Partially supporting Hypothesis 14, women in the Comic condition significantly increased the number of chemists they thought were women from Time 1 ( $M = 41.71$ ,  $SD = 16.11$ ) to Time 2 ( $M = 43.73$ ,  $SD = 18.23$ ;  $\text{mean difference} = 2.02$ ,  $SE = 1.00$ ,  $p = .045$ ). There were no other significant interactions: all  $p > .20$ .

Contrary to hypotheses (Hypothesis 13, Hypothesis 14), a 2 (Gender)  $\times$  2 (Condition)  $\times$  2 (Time) mixed ANOVA on percent of engineers that participants think are men found no significant main effects or interactions: all  $p > .09$ .



**Table 2**  
*Results for Main Hypotheses*

Hypothesis	Supported?	Result
Hypothesis 1: Comics will be more effective than text-only tweets at conveying awareness of gender bias in STEM (e.g., lowering the perception of the climate for women in STEM) compared to tweets.	No	$F(1, 431) = .34, p = .561, \eta_p^2 = .001$
Hypothesis 2: Women will be more aware of bias than men.	Yes	$F(1, 431) = 4.63, p = .032, \eta_p^2 = .01$
Hypothesis 3: Comics will be more transporting than tweets.	No; tweets more transporting	$F(1, 432) = 4.32, p = .038, \eta_p^2 = .010$
Hypothesis 4: Women will be more transported than men.	Yes	$F(1, 432) = 5.01, p = .026, \eta_p^2 = .011$
Hypothesis 5: Participants in the comic condition will report less negative emotion than participants in the text-only tweet condition.	No	$F(1, 432) = .044, p = .834, \eta_p^2 < .001$
Hypothesis 6: Women will report higher levels of empowerment than men, particularly in the Comic condition.	Partially; women more empowered, but no interaction with Condition	Gender: $F(1, 432) = 15.17, p < .001, \eta_p^2 = .034$ Interaction: $F(1, 432) = .04, p = .851, \eta_p^2 < .001$
Hypothesis 7: Women will be more likely to share than men.	Yes	$F(1, 432) = 22.82, p < .001, \eta_p^2 = .050$
Hypothesis 8: Participants will be more likely to share comics than tweets.	No	$F(1, 432) = 3.55, p = .060, \eta_p^2 = .008$
Hypothesis 9: Comics will be more effective than text-only tweets at decreasing derogation compared to tweets.	No; tweets more effective	$F(1, 427) = 4.70, p = .031, \eta_p^2 = .011$
Hypothesis 10: Women will engage in less derogation than men.	Yes	$F(1, 427) = 23.14, p < .001, \eta_p^2 = .05$
Hypothesis 11: Men's derogation will decrease in response to comics, but not tweets.	No	$mean\ difference = .020, SE = .044, p = .645$
Hypothesis 12: Women will feel more positively about the comic artist than men.	Yes	$t(216) = 3.62, p < .001, d = .49$
Hypothesis 13: After reading the messages, individuals will hold less stereotypic views of the gender distributions across professions (e.g., will report higher percentages of women chemists and engineers).	No	$F(1, 431) = 0.56, p = .453, \eta_p^2 < .01$
Hypothesis 14: Comics will have a stronger effect than tweets on decreasing stereotypic views of the gender distributions	Chemists: Partially, for women in the Comic condition Engineers: No	Chemists: $F(1, 431) = 5.74, p = .017, \eta_p^2 = .013$ Engineers: $F(1, 432) = 2.83, p = .093, \eta_p^2 = .006$

Note. STEM = science, technology, engineering, and mathematics.

## Exploratory Analysis on Percent of Nurses Who Are Men

An exploratory analysis examined perceptions of the number of nurses who are men. A 2 (Gender)  $\times$  2 (Condition)  $\times$  2 (Time) mixed ANOVA on percent of nurses that participants thought were men showed that men thought fewer nurses were men ( $M = 29.14, SD = 21.46$ ) and women thought more nurses were men ( $M = 32.75, SD = 17.29$ ), ( $F(1, 430) = 7.47, p = .007, \eta_p^2 = .02$ ). There were no other main effects or interactions: all  $p > .09$ .

## Exploratory Correlations

### Perceived Positive Climate in STEM

A set of exploratory partial correlations was conducted on associations between how people felt in response to the comics and tweets and the posttest scores for perceived positive climate in STEM among men and women (see Tables 3 and 4 for the raw correlation matrix). Transportation was not associated with negative perceptions of the climate for women in STEM for men ( $r = .14, p = .073$ ) or women ( $r = -.07, p = .260$ ). For both men ( $r = .32, p < .001$ ) and women ( $r = .37, p < .001$ ), higher scores on the posttest measure of derogation of women in STEM were

associated with seeing the climate as more positive. In terms of emotional responses, negative emotions were associated with seeing the climate as more negative, particularly for women ( $r = -.22, p < .001$ ; men  $r = -.14, p = .072$ ). Motivated emotions were not associated with climate perceptions for either men ( $r = -.14, p = .062$ ) or women ( $r = .05, p = .477$ ). Finally, women who felt amused were significantly more likely to see the climate as

**Table 3**  
*Pearson Correlations for Perceived Positive Climate in STEM Among Men*

Variable	1	2	3	4	5	6
1. Climate	—					
2. Derogation of women in STEM	.35**	—				
3. Negative emotions	-.22**	-.07	—			
4. Motivated emotions	-.27**	-.22**	.47**	—		
5. Amusement	-.04	0.09	0.03	.45**	—	
6. Transportation	-.06	-.18*	.26**	.53**	.39**	—

Note. STEM = science, technology, engineering, and mathematics.  
\* $p < .05$ . \*\* $p < .01$ .

**Table 4***Pearson Correlations for Perceived Positive Climate in STEM Among Women*

Variable	1	2	3	4	5	6
1. Climate	—					
2. Derogation of women in STEM	.41**	—				
3. Negative emotions	-.29**	-.15*	—			
4. Motivated emotions	0.00	-.16*	.38**	—		
5. Amusement	.28**	0.04	-.07	.46**	—	
6. Transportation	-.14*	-.25**	.28**	.37**	.27**	—

Note. STEM = science, technology, engineering, and mathematics.

\* $p < .05$ . \*\* $p < .01$ .

positive ( $r = .23, p < .001$ ), but there was no association of amusement and perception of climate for men ( $r = -.04, p = .611$ ).

### Willingness to Share

A set of exploratory partial correlations was also conducted on associations between how people felt in response to the comics and tweets (Transportation, Defensiveness, Negative Emotions, Motivation Emotions, Amusement) and Willingness to Share the comics and tweets (see Tables 5 and 6 for the raw correlation matrix). Women ( $r = .20, p = .001$ ) who experienced higher transportation were more likely to express willingness to share. The pattern among men was similar, but not significant:  $r = .13, p = .089$ . In addition, both men ( $r = -.23, p = .003$ ) and women ( $r = -.22, p < .001$ ) with higher levels of defensiveness (derogation of STEM women) were less willing to share the comic or tweet. Women who felt more negative emotions had greater willingness to share ( $r = .20, p = .002$ ), but there was no association between negative emotions and willingness to share among men ( $r = .05, p = .554$ ). However, motivated emotions were positively associated with willingness to share for both men ( $r = .33, p < .001$ ) and women ( $r = .18, p = .005$ ). Finally, amusement was positively associated with willingness to share, but only among women ( $r = .24, p < .001$ ), not men ( $r = .11, p = .172$ ).

### Discussion

In the current study, comics and text-only tweets were both able to shift attitudes toward women in STEM. First, viewing either comics or tweets about women in STEM increased awareness about the idea that women sometimes experience a negative climate in STEM and decreased defensiveness/derogation among

**Table 6***Pearson Correlations for Willingness to Share Among Women*

Variable	1	2	3	4	5	6
1. Willingness to share	—					
2. Derogation of women in STEM	-.28**	—				
3. Negative emotions	.32**	-.15*	—			
4. Motivated emotions	.45**	-.16*	.38**	—		
5. Amusement	.35**	0.04	-.07	.46**	—	
6. Transportation	.43**	-.25**	.28**	.37**	.27**	—

Note. STEM = science, technology, engineering, and mathematics.

\* $p < .05$ . \*\* $p < .01$ .

women, though men were more defensive overall. Second, women significantly increased the number of chemists they thought were women after viewing the comics, but not after viewing the tweets. Third, contrary to hypotheses, participants were more transported in response to the tweets than comics. Finally, as predicted, women felt more positively about the comic artist than men, were more transported than men, and were more willing to share what they saw.

Taken together, the present study demonstrates that posts on social media, both with and without illustrations, may increase awareness about biases against women in STEM; however, these posts were more effective for women, who may not always be the intended audience. In other words, although the comics and tweets both attempted to decrease defensiveness and increase engagement with the topic, the comics and tweets did not reach the male participants in the desired way. Because women share a social identity (gender) with women in STEM, women in general may be more receptive to messages about gender bias. This pattern suggests that additional research is needed to determine what type of messages are most effective for men or across genders.

Although the comics and tweets only decreased derogation among women, higher levels of derogation were associated with both men and women being less aware of the potentially negative climate in STEM. The association of derogation with a lack of awareness points to the importance of creating interventions that can reduce defensiveness in both men and women. However, experiencing negative emotions after seeing the comics and tweets was correlated with greater awareness. These findings contribute to theory by expanding the potential mechanisms by which comics (or tweets) might have an impact. Specifically, some types of comics may work through evoking more content-specific emotions (e.g., anger). The comics we used in this study may thus be analogous to political cartoons or serious graphic novels.

Consistent with previous research, higher arousal emotions were also associated with greater willingness to share the messages (Berger & Milkman, 2012), particularly among women. In addition, feeling motivated and empowered led to stronger sharing intentions. Although these feelings may not be captured in traditional emotion scales, the current research suggests that they are important to consider for messages related to bias or other social issues. Taken together, these results imply that communicators should carefully consider the specific emotions that might be evoked by their messages, and match the emotion to the desired outcome (e.g., creating feelings of anger to raise awareness or empowerment to encourage sharing).

**Table 5***Pearson Correlations for Willingness to Share Among Men*

Variable	1	2	3	4	5	6
1. Willingness to share	—					
2. Derogation of women in STEM	-.30**	—				
3. Negative emotions	.28**	-.07	—			
4. Motivated emotions	.57**	-.22**	.47**	—		
5. Amusement	.31**	0.09	0.03	.45**	—	
6. Transportation	.42**	-.18*	.26**	.53**	.39**	—

Note. STEM = science, technology, engineering, and mathematics.

\* $p < .05$ . \*\* $p < .01$ .

Amusement was associated with positive impressions of the climate for women in STEM, but primarily among women. This finding could be interpreted in a negative light, such that amusement may be leading people to discount the extent or seriousness of the problem (Nabi et al., 2007). On the other hand, for women, our posts may have inadvertently conveyed a dual message: on the one hand, they showed the bias that women experience, but on the other hand, they also may provide a sense of hope that others are recognizing and challenging these issues (so, they may have given a sense that the climate for women is improving because people are willing to speak up against these kinds of biases). In future studies, more detailed measures may be needed to differentiate between these possibilities and capture participant reactions in a more fine-grained way.

In addition, transportation was associated with greater willingness to share and less derogation, implying that narrative processing may be a fruitful way to create change, even with very brief messages. Message creators might consider how to capture STEM experiences in stories rather than declarative claims.

One area where comics seemed to be superior to text-only tweets was increasing perceptions of women chemists (among women). Although further replication is needed, these results suggest that visual media may be especially good at highlighting the representation of women in science. Audiences may be better able to think of women as scientists when they see images of women in science compared to reading about them.

## Limitations

One potential limitation of the present work was that women, compared to men, reported more positive emotions, which included amusement, in response to the comics and tweets. Thus, it is possible that the comics and tweets were less effective at shifting men's attitudes because they did not find them humorous enough. However, it is also possible that men found the comics and tweets less humorous than women *because* they were more defensive than women. An important implication of these findings is that it may therefore be difficult to craft messages that are equally humorous to men and women when they, on average, differ in their level of defensiveness to the message itself.

In addition, the present study measured willingness to share the comics and tweets, but did not measure actual sharing behavior. Although intentions can be useful for predicting behaviors, intentions are not always predictive of future behaviors (Sheeran, 2002). For example, individuals may agree with a tweet, but refrain from sharing it due to concerns about how friends or employers might react. Future research should consider using field methods to test how willing men and women are to share illustrated and text-only posts about gender biases.

Finally, although we suggest that the comics and tweets presented brief narratives, these are not fully-developed stories with long plot arcs or detailed characters; rather, they are anecdotes that capture common experiences of women in STEM. It is possible that increasing the story elements (for instance, by using a series of tweets or a multipanel comic strip) might increase the narrative processing and thus the effectiveness of these types of messages.

## Future Directions

A key consideration for future research on using comics is that humor can sometimes lead to the topic being taken less seriously. For instance, using humor within a complaint can increase positive perceptions of the complainer, but it can also lead to the complaint being less likely to be addressed and can reduce sympathy for the complainer (McGraw et al., 2015). In the present context, it is possible that humor may have made presence of bias against women in STEM seem relatively unimportant and not a social issue that needs addressing. As researchers continue to create interventions against gender biases, it will be important to consider when humor may be an asset in shifting attitudes and when it might backfire.

Another future direction would be to explore longer term effects. If participants in the present study were asked about their reactions to the comics and tweets in a long-term follow-up, there may have been a sleeper effect in which the comics or tweets became more effective for men. An additional benefit of comics may be that they create a mental image that may be more likely to endure in the audience's thoughts. Thus, future research should consider both the number of social media posts with the awareness-raising message as well as potential sleeper effects for the illustrated posts. Although our study used comics drawn by a professional comic artist, pictorial memes can be an accessible and low-cost way of creating and sharing visual images; future research might explore similarities and differences between professional comics and user-created or user-modified images.

Understanding how posts that might appear on social media affect attitudes toward biases is particularly important given the role of social media in social movements. By raising awareness through social media, individuals are able to create a sense of solidarity that can motivate change. For example, in 2006, Tarana Burke began the MeToo campaign against sexual harassment and sexual assault. When actress Alyssa Milano encouraged people to use the hashtag #metoo to share their experiences with sexual harassment and assault in 2017, the hashtag was tweeted about one million times within 48 hr (Garcia, 2017). As social media continues to rally individuals toward common causes, it will become increasingly important to examine how the social media posts within these movements are affecting both those within the movement as well as those the movements are targeted toward.

## Conclusion

The present study provides preliminary evidence that both comics and text-only tweets may be effective methods for raising awareness about gender biases in STEM fields. Both comics and tweets reduced defensiveness about gender biases and increased understanding about the climate for women in STEM. However, only comics were effective at positively changing women's beliefs regarding the number of women in STEM. These findings imply that brief social media postings can be an effective means of communicating about the challenges facing women in STEM. Furthermore, the finding that even text-only tweets can create change is encouraging, because for most communicators, it is much easier to compose a brief message than to create a comic panel or illustration. Importantly, the comics and tweets were most often effective with the women in the study, not the men. This highlights the potential difficulty of encouraging larger-scale change in bias-

related attitudes. Thus, it is important for future research to examine how to craft messages about women in STEM that will reach both men and women.

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