International Journal of Gender, Science and Technology
http://genderandset.open.ac.uk

"Where My Ladies At?": Online Videos, Gender, and Science Attitudes among University Students

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ABSTRACT
This study examines the impact of online videos on science attitudes that contribute to gender disparities in STEM participation. Its theoretical framework builds on research regarding media effects on science attitudes and gender schemas. In particular, it draws on social cognitive theory to argue that media models in science communication can influence audience members. A randomized experiment tested the effects of three videos from a YouTube channel, *The Brain Scoop with Emily Graslie*, on science interest, self-concept in science, science anxiety, perceptions of scientists, and perceptions of gender bias in science among university students. The results showed that a video in which a female communicator directly addresses sexism in science shaped university students' positive perceptions of scientists and perceptions of gender bias in science. More broadly, the findings reinforce both the challenges in promoting equitable gender representation in STEM and the promise of using new media forms such as YouTube science channels to address these challenges.

KEYWORDS
Science attitudes; online video; social media; YouTube; gender

"Where My Ladies At?": Online Videos, Gender, and Science Attitudes among University Students

On November 27, 2013, Emily Graslie, the host of the Chicago Field Museum's science-themed YouTube channel *The Brain Scoop*, posted a new video titled, "Where My Ladies At?" She begins the video by saying:

> Recently, I received a question for an "Ask Emily" episode along the lines of whether or not I had personally experienced sexism in the field. And I kind of shrugged it off … The more I thought about it, though, along with another question of is there any part of my job that I don't look forward to, I would have to say it would be the frustratingly negative and sexist comments I have to sift through in my various inboxes on a daily basis.

Graslie notes that, "while there are at least 13 STEM [YouTube] channels hosted by men with more than 400,000 subscribers … there are only four channels hosted by women that even have more than 160,000," and argues that the sexism women experience in science communication acts as a deterrent against their participation. To illustrate this sexism, a male co-host reads a number of comments she received, such as, "I'd still totally do her," "She just needs some sexier glasses," "I can't stop looking at her nose … it makes her look like a nerdy pig," and "You'd think this was a man's job." Calling such comments "internet bullying," Graslie asks viewers to "help us make it widely known that this … attitude is detrimental and unacceptable," encourages "more women to become content creators," and affirms her commitment to "provide for more women role models to fill these spaces."

Graslie's video highlights the challenge of "figur[ing] out ways we can best promote the work of female researchers in this male-dominated field." In 2013, women accounted for only 29% of science and engineering occupations, though the proportion ranged from 62% for social sciences and 48% for life sciences to 31% for physical sciences, 25% for computer and mathematical sciences, and 15% for engineering (National Science Board, 2016). Students' attitudes, along with a host of other institutional and individual-level factors pertaining to science, may contribute to such disparities (Blickenstaff, 2006). For example, science interest (Gokhale et al., 2015), self-concept in science (Desy et al., 2011; Riegle-Crumb et al., 2010), science anxiety (Desy et al., 2011), perceptions of scientists (Wyer, 2003), and beliefs about gender equality in science (Gokehale et al., 2015; Wyer, 2003) may shape participation in STEM (science, technology, engineering, and math) education and careers.

Graslie's choice of YouTube as her platform also reflects the growing prominence of social media and online video in science communication (see Brossard, 2013; Liang et al., 2014). Scientists increasingly use online video platforms such as YouTube (Shapiro & Park, 2015) and TED (Technology, Entertainment, and Design) Talks (Spartz et al., 2017; Sugimoto & Thelwall, 2013) to communicate with broader audiences. For their part, members of the public increasingly use internet sources,

including social media, to learn about science (Brossard & Scheufele, 2013; National Science Board, 2016). Though these platforms provide new opportunities for scientists to reach lay people, they may simultaneously reflect and reinforce existing gender disparities in STEM and science communication. Looking at YouTube science videos, Welbourne and Grant (2016) found that men were overrepresented relative to women as communicators and received marginally greater views. Moreover, Sugimoto et al. (2013) found that male-authored science videos received more YouTube views and "likes" than female-authored science videos did.

At the same time, Graslie's use of YouTube to challenge sexist comments reflects the increasing use of social media to address sexism against women in STEM (see also Steinke, 2013). Another example of this trend is the Tumblr site This Is What a Scientist Looks Like. Launched in 2012, the site posted user-submitted photographs of female scientists to challenge stereotypes of scientists as "old white guy[s] with crazy hair, glasses and a lab coat" (Wilcox, 2012). Yet another example is the response on Twitter to comments by Nobel Prize-winning British scientist Tim Hunt, who, at a 2015 conference, said, "Let me tell you about my trouble with girls … Three things happen when they are in the lab. You fall in love with them, they fall in love with you, and when you criticize them, they cry" (Chappell, 2015). Many female scientists reacted by posting pictures of themselves wearing lab gear, hazmat suits, and other work-related clothes, accompanied by the ironic hashtag "#distractingly sexy."

With all of this in mind, the present study uses *The Brain Scoop with Emily Graslie* as a case for exploring the potential impact of YouTube videos on science attitudes related to gender disparities in STEM participation among a key audience: undergraduate students. As a test case, Graslie's YouTube channel possesses several advantages. It carries institutional credibility through its association with the Chicago Field Museum of Natural History. It reaches a sizable audience; as of August 19, 2017, it had more than 400,000 subscribers. Of particular relevance to the purposes at hand, Graslie's "Where My Ladies At?" video directly addresses underrepresentation of and sexism against women in science. This video reached not only *The Brain Scoop*'s regular audience but also a wider audience due to coverage in news outlets such as National Public Radio, the Huffington Post, and the Daily Dot, as well as feminist websites such as Jezebel and STEM-related websites such as ScienceBlogs. Furthermore, many readers shared news articles about the video through social media platforms such as Facebook and Twitter. As of August 19, 2017, the video had received almost one million views on YouTube. Thus, it represents a prominent real-world effort at using social media and online video to communicate about sexism and gender equality in science.

In developing a theoretical framework, this study draws on research regarding how media messages can shape science attitudes and gender schemas. In particular, it builds on social cognitive theory to argue that media models – in this case, Graslie – can influence audience members. It then uses data from a randomized experiment to examine the impact of three *Brain Scoop* videos: one that explicitly addresses sexism in science and two that do not. The analyses test the effects of each video on a range of science attitudes. The results advance our understanding

of the prospects for using social media and online video to influence science attitudes and, ultimately, address gender disparities in STEM and science communication.

MEDIA MESSAGES AND SCIENCE ATTITUDES

Early studies regarding media effects on science attitudes drew on cultivation theory, which posits that dominant messages in television content shape viewers' perceptions of social reality. Gerbner et al. (1981) found that prime-time television depicted scientists as rare, disproportionately "strange," and disproportionately likely to die. Accordingly, the authors argued that overall television viewing would foster negative perceptions of science (see also Shanahan & Morgan, 1999). Subsequent research has argued that not only general television viewing but also science non-fiction television viewing, science-fiction television viewing, science magazine readership, newspaper readership, and internet use each shape science attitudes in distinctive ways (Brossard & Dudo, 2012; Dudo et al., 2011; Nisbet et al., 2002).

Whereas the aforementioned body of literature draws on survey data to show how habitual patterns of media use correlate with broad science attitudes, another line of research uses experimental data to demonstrate that single-shot exposures to messages within mass media can influence general science attitudes. For example, one study found that exposure to a single newspaper article about scientists influenced science interest among college students (Cheryan et al., 2013). Another study found that viewing a handful of short science-themed television clips in one sitting influenced future science career self-views among adolescents (Steinke et al., 2009).

Furthermore, recent experiments have found that single exposures to social media messages can influence attitudes about specific scientific topics. One recent study found that exposure to information and/or misinformation through Facebook shaped audience perceptions about vaccines and genetically modified organisms (Bode & Vraga, 2015). A second study found that experimentally varying the number of views of a YouTube video about climate change influenced viewers' perceptions of the importance that other Americans attached to the topic (Spartz et al., 2017). A third study showed that watching a satirical YouTube video about climate change influenced viewers' beliefs about global warming and their perceptions of scientific consensus on the subject (Brewer & McKnight, 2017).

However, research to date says relatively little about how social media and online video shape broader science attitudes, either among members of the U.S. population as a whole – 58% of whom used YouTube as of 2017 (Shearer & Gottfried, 2017) – or students in particular. The latter audience is particularly important given that several forms of social media use, including YouTube use, are highest among young people (Shearer & Gottfried, 2017). Given this pattern, STEM-themed YouTube channels may reach substantial numbers of university students. In the case at hand, the primary audience for *The Brain Scoop* is 13–18-year-old women (Potter, 2014), but undergraduate students are a key secondary demographic for both Graslie's online channel and her offline communication efforts

(Appleton, 2017). In March 2013, around half a year before the "Where My Ladies At?" video debuted, 18–24-year-olds comprised the second-largest age group among her viewers, after 13–17-year-olds (Graslie, 2013).

GENDER SCHEMAS, MEDIA MODELS, AND SCIENCE COMMUNICATION

Given that media messages can influence viewers' attitudes about both science and gender roles (Signorielli, 1989), it follows that such messages may contribute to gender disparities in STEM. Men consistently outnumber women in portrayals of scientists as characters in Hollywood films (Smith et al., 2013; Steinke & Taverez, 2017; Weingart et al., 2003), primetime television programs (Dudo et al., 2011; Smith et al., 2013), television programs for young children or adolescents (Long et al., 2010; Smith et al., 2013; Steinke & Long, 1996), and video games (Dudo et al., 2014). Furthermore, media messages tend to portray scientists in gender-stereotypical ways – for example, by focusing more on the appearances, sexuality, and romantic lives of female scientists (Smith, 2013; Steinke, 2005; Steinke & Tavarez, 2017) and by presenting male scientists as more likely to be independent, nerdy/geeky, and violent (Long et al., 2010).

Gender schema theory suggests that such gender stereotyping in media messages can influence participation in STEM careers. Research shows that people develop gender schemas, or cognitive structures about gender, in early childhood (Bem, 1993; Campbell et al., 2004; Steinke et al., 2006). People then use these schemas to store information in memory, interpret experiences, develop identities, and make decisions (Steinke, 2005). Gender schemas provide foundations for gender stereotypes, which children also develop at an early age (Campbell et al., 2004; Steinke, 2005) – for example, children tend to stereotype scientists as male and white (Barman, 1997; Finson, 2002; Fort & Varney, 1989). Given that many people have little social contact with real scientists, media portrayals can shape their gender stereotypes of scientists (Steinke, 2005; Steinke et al., 2007). Gender stereotypes of scientists, in turn, may influence science attitudes and, ultimately, pursuit of STEM careers – for example, such stereotypes may affect the development of students' "possible selves" as scientists (Ruvolo & Markus, 1992; Steinke et al., 2009).

Of particular relevance for the present study, social cognitive theory (Bandura, 1986) provides a framework for understanding the effects of media models on gender representation in STEM careers (Steinke, 2005). According to this theory, people learn attitudes and behaviors by observing and identifying with cultural models, including media models. The extent to which young people exposed to media models identify with and imitate them can depend on a range of environmental and individual factors – for example, models may exert more influence when they are of the same gender as the audience member and when they address issues that resonate with the interests and personal experiences of the audience member (Steinke, 2005). "Wishful identification" can be an important precondition to modeling, thus young people's identification with scientists in popular media may contribute to their interest in and pursuit of STEM careers (Steinke et al., 2012). Looking at wishful identification with scientist characters portrayed on television programs, one study found that adolescent boys reported

greater identification with male scientists than with female scientists, whereas adolescent girls reported greater identification with female scientists than with certain types of male scientists (Steinke et al., 2012).

USING MEDIA MESSAGES TO NARROW GENDER GAPS IN STEM

Although the gender stereotypes of scientists that have historically dominated popular media may contribute to gender disparities in STEM pursuits, media messages can also serve as tools for combating such stereotypes and fostering more positive science attitudes among women. Social cognitive theory suggests that media representations of female scientists could play important roles as behavioral models for female students (O'Keeffe, 2013; Steinke, 1998, 1999), particularly given that students report little personal contact with female scientists (Baker & Leary, 1995). Such representations may be most effective at changing attitudes when they challenge traditional gender stereotypes. One study found that women who read a newspaper story that portrayed computer scientists in a counter-stereotypical way expressed greater interest in computer science than those who read a story that reinforced gender stereotypes; meanwhile, men's interest was not influenced by the presence of stereotypical or counter-stereotypical portrayals (Cheryan et al., 2013).

Like traditional forms of media messages, internet content can serve to challenge gender stereotypes of scientists and provide models that encourage greater participation by women in STEM professions. When analyzing science and engineering websites for girls, Steinke (2004) found that such sites presented counter-stereotypical information and role models that could foster greater interest and participation in STEM. At the same time, some sites presented information about challenges facing women in STEM fields, including gender disparities and discrimination in these fields. The author suggests that, although such accounts "truthfully reflect the experiences of these women, [they] may still dissuade talented girls from pursuing careers in science, engineering, and technology" (Steinke, 2004, p. 22).

HYPOTHESES

In sum, research shows that media messages (Brossard & Dudo, 2012; Dudo et al., 2011; Gerbner et al., 1981; Nisbet et al. 2002), including messages in social media and online video (Bode & Vraga, 2015; Brewer & McKnight, 2017; Spartz et al., 2017), can influence science attitudes. Moreover, social cognitive theory suggests that counter-stereotypical portrayals of women in science can influence audience members by providing models with whom they can identify and, ultimately, emulate (O'Keeffe, 2013; Steinke, 1998, 1999). Thus, the present study hypothesizes that a YouTube video featuring a female scientist as a host can promote broad attitudes associated with participation in STEM:

> H1: University students who watch an online video featuring a female scientist will report greater science interest, greater science self-concept in science, and lower science anxiety than those not exposed to such a video.

> H2: University students who watch an online video featuring a female scientist will report more positive perceptions of scientists and fewer negative perceptions of scientists than those not exposed to such a video.

Studies also show that media messages and models can influence audience members' gender schemas regarding scientists (Steinke, 2005; Steinke et al. 2007). Extending this line of research, the present study hypothesizes that a YouTube video in which a female scientist describes and directly challenges underrepresentation of and sexism against women in STEM fields can influence perceptions of gender bias in science:

> H3: University students who watch an online video featuring a female scientist who explicitly addresses sexism in science will report greater perceptions of gender bias in science than those not exposed to such a video.

Building on evidence that women and men may respond differently to media messages that counter gender stereotypes of scientists (Cheryan et al., 2013), a research question asks:

> RQ1: Will the gender of the viewer moderate the effects of online videos featuring a female scientist?

METHODS

The data for this study came from a between-subjects experimental design conducted online from November 8 to December 3, 2015. The purpose for using such an approach was to follow other recent studies (Bode & Vraga, 2015; Brewer & McKnight, 2017; Spartz et al., 2017) in testing whether exposure to social media messages and online video can influence science attitudes. Although this method is limited in that it does not capture long-term effects of repeated viewing in a naturalistic setting, its strength lies in its capacity to demonstrate causal links between message exposure and attitudes.

The 311 participants were recruited from a public university in the Mid-Atlantic.[1] Of the participants, 71% identified as women, 29% as men, and fewer than 1% as other. The median age was 20 years. In terms of race and ethnicity, 86% self-identified as White, 7% as African American, 6% as Asian/Pacific Islander, 4% as Hispanic, and 1% as Other (participants could select multiple categories; some did not self-identify). When asked whether they were a major in a science, technology, engineering, or math field, 22% said yes and 78% said no. On a five-category scale measuring political beliefs, 12% identified as very liberal, 32% as liberal, 36% as moderate, 17% as conservative, and 2% as very conservative. The recruitment method and nature of the sample raise potential concerns about the generalizability of the results – an issue that the conclusion revisits.

Treatments

Participants were told that they would be asked to view a video. To minimize demand characteristics, the instructions stated that they would be asked "some questions about the video." Furthermore, the posttest (see below) described the

measures of the dependent variables as "background questions." Each participant was then randomly assigned to one of three treatment conditions or a control condition. In each treatment condition, respondents viewed a different video from *The Brain Scoop with Emily Graslie.* Each video was around six minutes in length.

Participants in the first treatment condition (n = 75) viewed the aforementioned *Brain Scoop* video titled "Where My Ladies At?" This video was selected as one in which the host explicitly addresses sexism in science and science communication.

The other two treatment videos were selected to represent Graslie's more typical science content, which usually follows one of two formats: standard videos in which Graslie discusses a specific topic related to zoology, taxidermy, and/or museums, or "Ask Emily" videos in which she answers viewer questions. The inclusion of both a standard video and an "Ask Emily" video as treatments provided two different comparison points in testing for any unique effects of Graslie's message about sexism in the "Where My Ladies At?" video, which also features responses to viewer feedback (albeit in a different way than a typical "Ask Emily" video).

Participants in the second treatment condition (n = 82) viewed a September 11, 2013, *Brain Scoop* video titled "Ask Emily #5." In this video, the host reads questions from her viewers and responds to them, including questions about biology, dissections, and taxidermy (e.g. "When dissecting an animal, do you often go through the contents of its stomach?"); the Field Museum, where Graslie works (e.g. "Is there a part of the museum that you feel is underrated?"); and Graslie's personal experiences and perspectives ("What do you see as your mission in life?").

Participants in the third treatment condition (n = 77) viewed a June 4, 2014, *Brain Scoop* video titled "Where'd You Get All Those Dead Animals?" In this video, the host describes how the Field Museum acquires animal specimens for dissection and preparation. She also defines what "voucher specimens" are, explains why they are useful to scientists and museums, discusses controversy about their collection, and describes government regulations and ethical codes regarding their collection.

Participants in the control condition (n = 77), which served as the baseline for comparison, did not watch a video about science. Instead, they watched a video from a satirical comedy program, *Last Week Tonight with John Oliver*, on an unrelated topic (dogs dressed as U.S. Supreme Court justices), which was also around six minutes in length.

Posttest

The posttest included questions on a variety of topics, some of which served to disguise the study's purpose. Measures for the attitudes of interest were as follows (see the appendix for full question wording).

Science interest was measured through an index constructed by averaging scores across five items asking about interest in science, science media, and science careers (α = .93).

Self-concept in science was measured through an index constructed by averaging scores across three items adapted from the relevant subscale of Weinburgh and Steele's (2000) Modified Attitudes Towards Science Inventory (α = .83).

Anxiety toward science was measured through an index constructed by averaging scores across three items adapted from the relevant subscale of Weinburgh and Steele's (2000) Modified Attitudes Towards Science Inventory (α = .87).

Positive perceptions of science were measured through an index constructed by averaging scores across two items adapted from the National Science Board's (2014) Science and Engineering Indicators (α = .67).[2]

Negative perceptions of science were measured through an index constructed by averaging scores across four items adapted from the National Science Board's (2014) Science and Engineering Indicators (α = .71).

Perceptions of gender bias in science were measured through an index constructed by averaging scores across five items original to the present study (α = .82).

To facilitate further exploration of potential psychological mechanisms underlying any effects of the videos on science attitudes, the posttest also included an open-ended question asking respondents to describe, in their own words, their reaction to the video they had just watched. This question appeared at the beginning of the posttest, immediately after participants had viewed the video for their condition.

RESULTS

A series of one-way ANOVAs tested whether science attitudes differed across the experimental conditions. Table 1 reports the results of these tests, as well as the mean for each variable in each condition along with results from Bonferroni post-hoc tests.

No significant difference across conditions emerged at the .05 level for science interest, $F(3, 305) = .79$; self-concept in science, $F(3, 302) = 1.35$; or anxiety toward science, $F(3, 302) = .31$. Thus, the results did not support H1: none of the three videos discernibly influenced science interest, self-concept, or anxiety.

Positive perceptions of scientists differed across conditions, $F(3, 304) = 3.77$, $p < .01$. The post-hoc tests showed that participants who watched the "Where My Ladies At?" video reported more positive perceptions of scientists than those in the control condition (.24 on a 1–4 scale; $p < .05$; Cohen's d = .42) or those who watched the "Ask Emily #5" video (.20 on a 1–4 scale; $p < .05$; Cohen's d = .35). Both of these effects were small to moderate by conventional thresholds (see Cohen, 1977). No other significant differences across conditions emerged for positive perceptions of scientists, nor did negative perceptions of scientists differ significantly across conditions, $F(3, 303) = .61$. Thus, the results partially supported H2. Watching a video in which a female scientist explicitly addresses sexism in science increased positive perceptions of scientists but did not reduce

negative perceptions, whereas watching the other videos had no discernible impact relative to the control condition.

Table 1: Science attitudes, by experimental condition

	Treatment: "Where My Ladies"	Treatment: "Ask Emily"	Treatment: "Dead Animals"	Control: No science video	*F* (d.f.)
Science interest	2.68[a] (1.15) *n* = 75	2.67[a] (1.07) *n* = 82	2.85[a] (1.12) *n* = 77	2.58[a] (1.10) *n* = 75	.79 (3, 305)
Self-concept of science	2.54[a] (.62) *n* = 73	2.55[a] (.64) *n* = 82	2.66[a] (.59) *n* = 77	2.45[a] (.69) *n* = 74	1.35 (3, 302)
Science anxiety	2.20[a] (.79) *n* = 74	2.17[a] (.72) *n* = 81	2.13[a] (.67) *n* = 77	2.25[a] (.82) *n* = 74	.31 (3, 302)
Positive perceptions of scientists	3.36[a] (.49) *n* = 74	3.16[b] (.41) *n* = 82	3.19[ab] (.53) *n* = 77	3.12[b] (.43) *n* = 75	3.77** (3, 304)
Negative perceptions of scientists	1.97[a] (.46) *n* = 73	2.08[a] (.56) *n* = 81	2.03[a] (.53) *n* = 77	2.05[a] (.53) *n* = 76	.61 (3, 303)
Perceptions of gender bias	3.02[a] (.48) *n* = 74	2.71[b] (.57) *n* = 79	2.71[b] (.55) *n* = 75	2.90[ab] (.44) *n* = 75	6.50** (3, 299)

Note: Table entries are means, with standard deviations in parentheses. Means in the same row that do not share superscripts differed significantly at the .05 level in Bonferroni post-hoc tests.

Perceptions of gender bias in science differed significantly across conditions, $F(3, 299) = 6.50$, $p < .01$. The post-hoc tests showed that participants who watched the "Where My Ladies At?" video reported greater perceptions of gender bias than those who watched either of the other treatment videos (for each, .31 on a 1–4 scale; $p < .01$; Cohen's d = .56). Both of these effects were moderate to strong (see Cohen, 1977). No other significant differences across conditions emerged for this variable. The results here yielded partial support for H3, with the clearest differences in bias perceptions emerging between those who watched a video in which a female scientist explicitly addresses sexism in science and those who watched a video in which the same host does not do so.

A series of two-way ANOVAs tested whether the gender of the viewer moderated the effects of the treatments on science attitudes. These analyses revealed that women reported lower science interest, $F(1, 300) = 8.54$; lower self-concept of science , $F(1, 297) = 11.54$; greater science anxiety , $F(1, 297) = 7.19$; and

greater perceptions of gender bias , $F(1, 294) = 33.21$, than men did ($p < .01$ for each). Such patterns are consistent with previous research (e.g. Darisi et al., 2010; Gilmartin et al., 2006; Hazari et al., 2013; Jones et al., 2000; Weinburgh, 1995; Williams & George-Jackson, 2014). However, the gender of the viewer did not significantly moderate the effect of the experimental manipulation on any of the dependent variables. In response to RQ1, the results produced no evidence that the effects of the videos on science attitudes differed depending on the viewer's gender.

An exploratory examination of the open-ended comments among participants who watched the "Where My Ladies At?" video suggests that some female viewers personally related to Graslie and her message. For example:

> As a female, I felt a connection to what she was saying.
>
> As a woman studying in the STEM field, this really hit home.
>
> I appreciated this video because, as a female in a STEM major who has female friends in STEM majors as well, sexism is something we are all too familiar with.
>
> I found the video to be super-relatable to the sexism in today's society … I have personally noticed the amount of video views when a woman is the main speaker to be significantly less than a man speaker.
>
> I can relate to the video. I have 700k followers on my Vine account and I see sexist comments like this all the time.
>
> As a female who is a frequent user of YouTube, I see stuff like that all the time.
>
> PREACH! I'm an average-looking female in the top 5% of my class. I feel I have to speak louder and longer just to be heard or not be reduced to the appeal of my outfit that day. I can relate and appreciate the conversation.

Such comments point to one potential mechanism by which the video may have influenced some viewers: by providing a media model of a woman in STEM whose experiences of sexism resonated with their own and with whom they could identify.

In contrast, none of the male participants who watched the "Where My Ladies At?" video wrote about relating to or identifying with Graslie. Indeed, some actively challenged her message. For example, one wrote, "Both our culture and probably biology lean women away from STEM at a young age, so just to be devil's advocate, I'd say … many women happily choose not to go into STEM, and the statistics of low women in STEM are not entirely due to sexism." Other men affirmed Graslie's message but did not personalize it in the way that some of the women did; as a case in point, one man wrote, "I am happy she is bringing attention to this issue.

She is a critical step in bringing gender equality throughout careers, not just STEM."

Furthermore, neither female nor male participants wrote comments about identifying with Graslie in response to the other two *Brain Scoop* videos. The open-ended comments from participants in these two conditions focused largely on how much they learned from the video they watched (e.g. "actually taught me more about the Field Museum than I expected to learn," "I felt slightly informed about facts of random information"), how interesting or entertaining they found it to be (e.g. "surprisingly engaging," "boring," "funny," "unamused"), and/or what they thought of Graslie's personality and communication style (e.g. "enthusiastic," "goofy," "tacky and cheesy," "quirky," "strange," "intelligent").

CONCLUSION

Taken as a whole, the results of this study suggest that watching a YouTube video that directly addresses sexism in science led participants to hold more positive perceptions of scientists (relative to the control video as well as one of the other treatment videos) and perceive greater gender bias in science (relative to the other treatment videos).[3] Both findings follow from theoretical accounts of media effects on general science attitudes (e.g. Brossard & Dudo, 2012; Dudo et al., 2011; Nisbet et al. 2002) while also extending another line of previous research (e.g. Bode & Vraga, 2015; Brewer & McKnight, 2017; Spartz et al., 2017) to show how social media and online video can influence such attitudes.

Furthermore, the findings speak to theoretical accounts that draw on social cognitive theory to argue that media models in science communication can shape audience members' attitudes and gender schema (O'Keeffe, 2013; Steinke, 2005; Steinke et al. 2007). Participants' open-ended responses suggested that some female viewers related personally to both Emily Graslie herself and the experiences of sexism she described in the "Where My Ladies At?" video. Thus, she may have fostered greater awareness of gender bias in STEM and broader positive perceptions of scientists in part by validating these audience members' own observations of gender discrimination and providing a model of a female scientist with whom they could identify (see Steinke et al., 2012). Specifically, she may have modeled how women can understand their own potential experiences of sexism in STEM as reflecting systemic problems rather than resulting from their own personal flaws or limitations. She may also have served as a model of a woman who has cultivated a successful career in science despite the systemic barriers that she has faced.

The results here highlight the possibility of using online video and social media to raise awareness of – and help counter – the ongoing challenges that women face in STEM fields. In particular, the finding that viewing the "Where My Ladies At?" video shaped perceptions of gender bias without significantly diminishing science interest or self-concept in science, and without significantly increasing science anxiety, suggests the potential for using these communication tools to address gender bias in STEM professions in ways that do not generate broader negativity toward science. Although previous research has raised concerns that internet-based

personal accounts of gender discrimination in STEM careers may dissuade women from pursuing these professions (Steinke, 2004), the only other discernible effect of viewing the "Where My Ladies At?" video was an increase in positive perceptions of scientists. This result implies that female scientists who provide models of how to challenge sexism in STEM can help *improve* scientists' image among students.

In drawing conclusions from the present study, it is important to consider its limitations. One set of limitations revolves around the selection of Emily Graslie's *The Brain Scoop* as a test case. Graslie herself is a relatively young white woman; thus, one should be cautious in generalizing the impact of her messages to communicators with other socio-demographic characteristics. Similarly, the effects of online science videos could differ for communicators with different personal communication styles. In addition, it bears emphasizing that Graslie and *The Brain Scoop* focus primarily on the life sciences, where participation by women is relatively high (National Science Board, 2016). Viewers might respond differently to online science videos in which female hosts discuss STEM fields where participation by women tends to be lower, such as the physical sciences, computer and mathematical sciences, and engineering (National Science Board, 2016). Thus, future research could build on the present study by testing the effects of other sorts of messages, presented by other communicators in other STEM fields. Such research could examine the effects of both real-world messages (as done here, thereby enhancing the external validity of the results) and constructed messages (allowing researchers to isolate which specific message features produce effects).

Another set of limitations revolves around the demographics of the sample for the study. The university students who participated in the study were mostly female and mostly white; as a result, the results presented here may obscure differences across gender (see Cheryan et al., 2013) as well as race and ethnicity (see Gilmartin et al., 2006; Riegle-Crumb et al., 2010) in how viewers respond to online science videos. Nor does the study's sample allow for exploring the potential role played by the "double bind" of intersecting sexism and racism that women of color experience in science (Malcom et al., 1976; Ong et al., 2011). Moreover, one should be cautious in generalizing the present study's results to other age groups, including school-aged children. To address these limitations, future studies could test the effects of online science videos among more diverse audiences.

A third set of limitations revolves around the indices used to measure science attitudes, some of which had modest levels of reliability, were constructed from relatively few items, and/or may have captured multidimensional constructs. Future research could incorporate additional survey items to enhance the measurement of these attitudes (e.g. Wyer et al., 2010).

A final set of limitations to consider is that the experiment assessed only the short-term impact of one-time exposure to online science videos. Thus, the results do not capture the longer-term impact of such exposure. Nor do they capture the impact of repeated exposure to online science videos over time.

Building on this last point, one potential implication of the results here is that exposure to a single video can influence some attitudes that shape participation in STEM (perceptions of scientists and of gender bias) without necessarily shaping others (interest, self-concept, and anxiety). Interestingly, the former attitudes revolve around perceptions of others whereas the latter revolve around the self. Thus, the failure of the videos to increase science interest, foster self-concept of science, or reduce science anxiety could reflect the difficulties in altering such self-directed attitudes through a single message – an outcome that dovetails with other studies finding that one-time interventions are not always sufficient to influence science attitudes (Steinke et al., 2006; 2007). More sustained interventions and/or different sorts of messages may be necessary in using social media and online video to affect some types of attitudes associated with STEM participation (Steinke et al., 2006; 2007). Indeed, social media platforms such as YouTube channels may allow science communicators to disseminate multiple messages over time to a range of audiences. Future research could pursue this possibility.

Keeping in mind the aforementioned caveats, the findings presented here both reinforce the ongoing challenges in promoting more equitable gender representation in STEM and science communication, and point to the promise of using new media forms such as YouTube science channels to address these challenges. At the end of the "Where My Ladies At?" video, Graslie says, "Ladies, it gets better!" Her own message and others like it could play a role in making STEM a better environment for women.

APPENDIX: QUESTION WORDING FOR MEASURES OF SCIENCE ATTITUDES

Please indicate how interested you are in each the following (1 = not at all; 2 = not very much; 3 = somewhat; 4 = a good deal; 5 = a great deal):

Science interest: (a) Science; (b) Watching TV shows about science; (c) Watching online videos about science; (d) A career that involves science; (e) A career that involves communicating about science.

Please indicate whether you agree or disagree with each of the following statements (1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree):

Self-concept of science: (a) Science is easy for me; (b) I usually understand what we are talking about in science; (c) I have a good feeling toward science.

Anxiety toward science: (a) It makes me nervous to even think about doing science; (b) It scares me to have to take science classes; (c) I do not do very well in science classes.

Positive perceptions of scientists: (a) Scientists are helping to solve challenging problems; (b) Scientists are dedicated people who work for the good of humanity.

Negative perceptions of scientists: (a) Scientists are apt to be odd and peculiar people; (b) Scientists have few other interests than their own work; (c) Scientists

don't get as much fun out of life as other people do; (d) A job as a scientist would be boring.

Perceptions of gender bias in science: (a) Gender bias against female scientists is rare [reverse coded so that disagreement indicated greater perception of gender bias]; (b) Women are underrepresented in science; (c) Women who communicate publicly about science often receive sexist comments; (d) Media portrayals of scientists often include gender stereotypes; (e) Women are treated differently than men in science.

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ENDNOTES

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[1] The study was approved by the Institutional Review Board of the authors' institution.

[2] When the six items measuring perceptions of scientists were included in the same index, the resulting index was less reliable ($\alpha = .50$) than either of the component

indices. Accordingly, the main analyses treated positive and negative perceptions separately. For the two items measuring positive perceptions, $r = .51$.

[3] The contrast in perceptions of gender bias in science among participants who viewed the "Where My Ladies At?" video and those who viewed either of the other two *Brain Scoop* videos could reflect not only the explicit content of the former but an implicit message of the latter (i.e. the presence of the female host in the video could imply that women have opportunities to participate in science). Future research could explore the latter possibility in more depth.