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EDITED BY
Amy May,
University of Alaska Fairbanks,
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REVIEWED BY
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Pontifícia Universidade Católica de
Minas Gerais, Brazil

*CORRESPONDENCE
Charisse L'Pree Corsbie-Massay
clcorsbi@syr.edu

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The role of media professionals in perpetuating and disrupting stereotypes of women in Science, Technology, Engineering and Math (STEM) fields

Charisse L'Pree Corsbie-Massay[1]* and Michele G. Wheatly[2]

[1]S.I. Newhouse School of Public Communications, Syracuse University, Syracuse, NY, United States, [2]Department of Biology, Syracuse University, Syracuse, NY, United States

Women continue to be underrepresented in the Science, Technology, Engineering and Mathematics (STEM) fields despite efforts to enhance interest and persistence at all levels in the educational pipeline. The "chilly" climate documented for girls and women in STEM exists within a broader communication climate established and reinforced by media professionals. The present study examined the role of media professionals in perpetuating stereotypes of women in STEM through two approaches (1) conducting interviews with seventeen STEM women about their engagement with media professionals and (2) surveying 105 media professionals about their stereotypes about science and scientists. STEM women report positive interactions with the media despite incidents of unprofessionalism, dissonance between the processes and pace of science vs. the media, an undercurrent of issues pertaining to gender and other forms of representation, and an ethical responsibility to engage with media. The survey of media professionals revealed persistent stereotypes about scientists across both genders, and these stereotypes were more pronounced among those who engaged with science as part of their job, particularly among those working in entertainment and advertising and those working outside of journalism and social media. To establish greater equity in STEM fields and the knowledge pipeline, communication scholars must investigate the role of media professionals in this process and consider best practices to disrupt media stereotypes about STEM women.

KEYWORDS

gender, stereotype, discrimination, STEM, women in STEM, media, journalism, journalists

Introduction

The knowledge economy workforce continues to experience underutilization of Science, Technology, Engineering and Math (STEM) professionals who identify as women; women constitute half the workforce in the United States, but just over a quarter of STEM professionals identify as women (Martinez and Christnacht, 2021).

This trend is further exacerbated by racial and socioeconomic marginalization (Martin et al., 2016; Wilkins-Yel et al., 2019). The current research project aims to understand how communication climate dynamics impact women in STEM. While young girls and women face significant barriers in their journey from early interest through educational attainment into STEM careers, media are a contributing factor at every stage along the "leaky pipeline" (Liu et al., 2019) whereby women do not advance through STEM careers.

Media representations—and larger public discourse—can directly and indirectly (e.g., family, friends, colleagues) discourage young girls from considering STEM careers, taint their experiences within STEM fields, and impact recruitment and retention of women pursuing STEM education, further exacerbating gender inequity. Media representations can perpetuate the myth that STEM fields are hard, competitive and demanding, better aligned with the asocial "loner" stereotype associated with introverted white males and not appealing to women who value work/life integration especially those who intend to combine their career with family obligations (Burlew and Johnson, 1992; Lips, 1992; Nauta et al., 1998; Myers and Major, 2017). Women working in STEM fields are the target of microaggressions (Yang and Carroll, 2018; Kim and Meister, 2022), subtle and contemporary forms of discrimination (Sue et al., 2007) that reinforce the historical exclusion of women in STEM.

In recent years, scientists from marginalized backgrounds have sought to change their representation through workplace and discipline-specific interventions (Kim and Meister, 2022; Moors et al., 2022), targeted industry journals (Wheatly, 2020) and social media endeavors like #thisiswhatascientistlookslike and I Am A Scientist (iamascientist.info). However, biases and stereotypes continue to pervade mainstream media representations revealing a major disconnect between those working in STEM fields and media professionals (including those working in and training for journalism, entertainment, advertising, and public relations). Although much of the prior research regarding the communication climate impacting gender and STEM has focused on the stereotypes and prejudices toward women in STEM, it is essential to consider how these stereotypes are produced and reinforced through media producers, arguably the missing link in this conversation.

Using two studies that employ qualitative and quantitative empirical research, in the present study we document the communication climate experienced by STEM women in their interactions with media producers as well as the communication climate that media professionals perpetuate. Study 1 features interviews with women working in STEM fields regarding their interactions with media professionals to better understand the production of media stereotypes. Study 2 surveys media professionals' stereotypes of science, scientists, and women in STEM fields to assess how these stereotypes manifest in this unique population. Together these studies will open a new avenue of research that focuses on communication as a tool to disrupt the media climate around women and others marginalized in STEM fields. Understanding how women in STEM engage with media professionals and likewise how media producers engage with scientists can help patch the leaky pipeline for women and other marginalized groups by providing a communication climate that advances the competitiveness of the United States.

Prior literature

The idea that women do not "belong" in science, technology, engineering, and math fields is rooted in a deep-seated history of gender as a social construct. For millennia, women were expected to work inside the home advancing the family whereas men were tasked with working outside the home in social, technical, and political endeavors. This, coupled with gendered stereotypes about cognitive and emotional capacity (i.e., women are stereotyped as less logical and more emotional compared to men), reinforced pervasive gendered labor norms long before the media industry environment of the twentieth and twenty-first centuries. As media industries evolved and proliferated, content created in these spaces reinforced these gender dynamics, creating a circular loop: women are assumed to be less intelligent and oriented toward domesticity, therefore, they are portrayed as less intelligent and more oriented toward domesticity, discouraging them from careers that require intelligence or are seen as in conflict with expectations of domesticity.

The representation of STEM professionals in media is complicated. Although scientists are generally portrayed as "brilliant" (Dudo et al., 2011; Geena Davis Institute on Gender in Media, 2019), they are also framed as socially inept loners (Steinke, 2017). The societal labels commonly used to group STEM professionals such as "geek", "nerd" or "dweeb" do little to promote inclusion or challenge social norms (Cheryan et al., 2009). The numbers of women scientists in media have increased across media content (Benson-Greenwald et al., 2021) and children's media effortfully represent scientists who are women (Previs, 2016), but demographic stereotypes about scientists—as white, middle-aged men—have persisted (Ferguson and Lezotte, 2020).

In popular films, men continue to outnumber women as scientists (Steinke and Tavarez, 2017; Geena Davis Institute on Gender in Media, 2019) despite the fact that women make up half of those employed in certain STEM subfields (Fry et al., 2021). Characters in the physical sciences were twice is likely to be men and characters in engineering were more than five times as likely to be men. Although these numbers are objectively small, they still misrepresent reality: women constitute 40% of physical science and 15% of engineering jobs (Fry et al., 2021). At the same time, where representations of women occur in

popular films, they were more likely to be white, attractive, not a mother, and employed as a biologist or astronaut, perpetuating the stereotypes that a career in science is incompatible with family life.

In journalism, women are less likely to be featured as experts (Zoch and Turk, 1998; Armstrong, 2004; The Global Media Monitoring Project, 2015) despite the fact that some studies have demonstrated that audiences find men and women equally competent and persuasive as experts (Greve-Poulsen et al., 2021). This absence of women as experts and sources has become palpable in the era of social media wherein people share and comment on stories, calling out articles, journalists, and outlets that fail to feature women. Stories where women are featured are amplified by audiences hungry for gender equality (Taub and Fisher, 2018) and journalists themselves write stories about holding themselves accountable (Lafrance, 2013, 2016; Yong, 2018).

Even studies in the subspecialty field of science journalism revealed gender disparities. Profiles of scientists in *The New York Times* featured gender parity, but profiles on women were more likely to address issues of work/life integration compared to men (Mitchell and McKinnon, 2019). Another analysis conducted by Benson-Greenwald et al. (2021) found that the gender of a scientist did not significantly impact the framing of the individual and the process of science in *The New York Times* and *The Scientist* magazine. Quotes in *Nature* articles were skewed toward men (Davidson and Greene, 2021) and women were underrepresented as COVID-19 experts tapped for commentary in United States' newspaper articles compared to their representation as healthcare professionals, public health experts, and STEM scientists (Fletcher et al., 2021). In social media, women were markedly absent from the 391 most popular STEM channels on YouTube, with <10% of hosts presenting as female (Amarasekara and Grant, 2019).

Little research has explored the demographic representation of scientists in advertising in the United States. This is surprising given the emphasis on scientific appeal as an advertising strategy (Thorndike, 1911). Although mainstream ads that feature scientists (broadly defined, including engineers, doctors) are abundant, no published content analysis to date systematically investigates the demographic compositions of scientists in mainstream advertising. Several specific areas have received unique attention, including direct to consumer drug marketing (Tsai and Lancaster, 2012) and e-cigarette retail websites (Grana and Ling, 2014), as well as case studies of diversity fails like the 2013 Volkswagen Super Bowl ad (Plank, 2014).

Alternatively, advertising for science and science related careers has been shown to disproportionately target men (Lambrecht and Tucker, 2019), creating a loop wherein women are used as objects of desire to persuade audiences that are conceptualized as men. This approach is a classic strategy that assumes an audience of heterosexual (often white, cis-gender, middle-class to upper-class, and able-bodied) audiences that results in the "male gaze," a term coined by Mulvey (1989) that refers to the presentation of women given this constructed audience (and producer).

These disparities are rooted in stereotypes of women as well as stereotypes of science among the general public. Science has been stereotyped as a highly demanding and lonelier domain (Lips, 1992) that is better aligned with personality traits exhibited by men. Women, who are generally regarded as less competent in abstract mathematical modeling and better suited to teamwork are not considered the "science type." Furthermore, women who publicly communicate about their STEM work are also more likely to be "stereotyped as 'bitchy', 'bossy', and 'emotional'" even by other women (McKinnon and O'Connell, 2020), a vulnerability that is amplified by a media environment wherein audiences can freely critique scientists and experts in social media (including social networking sites and in comments sections) without accountability. Research has demonstrated that this prevents women from promoting their own work, which contributes to cumulative career disadvantage (Weisshaar, 2017; Casad et al., 2021).

Efforts to disrupt the impacts of these media trends have focused on encouraging STEM interest among young girls (Dasgupta and Stout, 2014; Cheryan et al., 2015), disrupting gendered expectations among parents, teachers, and caregivers (Lipman et al., 2021); providing support to young women in college who are studying in STEM fields (Šaras et al., 2018) and creating inclusive workplaces for STEM practitioners including faculty (Laursen and Austin, 2020). Taken together these efforts are aimed at "unclogging the pipeline" (Van Miegroet et al., 2019), but assume that the stereotypes in media will continue unabated. Few scholars have addressed the upstream issue: the ongoing narrow representation of women in STEM by media professionals.

This is different from science communication, which actively seeks to improve science discourse among lay audiences. Media—within and outside of science communication—can perpetuate existing biases both because of stereotypes held by the media producers as well as the structural sexism upon which the media industries have been built. A review of women experts in British broadcast news reveals that fast-paced news production processes and social perceptions of proficient women as "pushy" work together to stymie efforts to diversify gender representation (Howell and Singer, 2017). In entertainment, a lack of personal knowledge of the field may cause writers and producers to construct messages that are derived from stereotypes in the interest of expedience and audience familiarity (Mayer et al., 2009; Butsch, 2017). Content that is "familiar" or "relatable" is more likely to attract audiences, which often means reinforcing the status quo (Gilchrist, 2010; Hunt, 2019). This tendency can be extremely difficult to combat, even among dedicated media producers. In a series of interviews with Black media producers, Corsbie-Massay et al. (2022) reveal that stakeholders want to disseminate authentic representations

of Blackness, but their stereotypes prevent them from seeing the viability of counter-stereotypical narratives.

In the past, the traditional "leaky pipeline" argument has focused on what is happening within the STEM pipeline itself, namely the "chilly" climate (Rosser, 2017) that limits the interest of girls and women in science, their perseverance, and ultimately, their retention and success. However, media representations of women in science can contribute to the leaky pipeline through "chilling" the external communication climate as well as affecting the attitudes of people within the STEM disciplines (Thébaud and Charles, 2018). Media stereotypes affect girls and women directly by inhibiting the vision they have for their own lives, but they can also cause peers, professors, and mentors to discourage girls and women from pursuing and advancing in STEM careers. For early and mid-career scientists, media coverage—specifically in journalism and news outlets—can impact tenure and promotion (Moher et al., 2018; Schimanski and Alperin, 2018), as well as opportunities in industry, meaning that disparities in coverage can affect disparities in advancement as well as fewer role models for girls and younger women.

Disrupting this vicious cycle requires a systematic focus on how the stereotypical and faulty representations of women in STEM are produced. Little work has systematically explored how media professionals reinforce stereotypes of women in STEM. Although the ethics of both science and journalism—as well as media at large as a representation of reality—are rooted in objectivity and positivism, it is clear that the process by which certain messages and people are amplified is subjective, maintaining a hegemonic status quo. Therefore, disrupting the communication climate to promote equity and inclusion in STEM must begin with documenting stereotypes of women in STEM held by media professionals, as well as how these stereotypes are reproduced in practice. We report exploratory research that addresses two primary research question:

> Research Question 1: What are the experiences of women working in STEM when engaging with media professionals?
> Research Question 2: What are the trends among media professionals regarding their engagement with science (both as a member of the public and as a media producer) and their stereotypes of science and scientists?

The goal of the current work is to understand the communication dynamics constructed and reproduced outside science and STEM industries. It is our hope that this exploratory investigation will launch research regarding the role of media to disrupt gender inequities in STEM by creating positive communication climates for women in STEM. Media have a unique role in combatting the leaky pipeline phenomenon, which in turn would contribute to growing the knowledge economy in the United States.

Study 1

The first study explores the interactions between women working as STEM practitioners and media professionals through a series of semi-structured interviews with women in STEM. This study begins to assess trends in these interactions that may contribute to the underrepresentation or the misrepresentation of women in STEM.

Interviewees

During summer of 2022, seventeen cis-gendered women who self-identified as scientists or science practitioners were interviewed about their experiences with media professionals. Interviewees were recruited through the authors' professional networks and snowball sampling. Interviewees ranged in age from 29 to 68 years of age ($M = 47.2$, $SD = 10.9$). Thirteen interviewees self-identified as white or Caucasian, three identified as Black or of African descent, one of Asian descent, one of Mexican descent, and one of Jewish descent. Although sexuality was not formally requested, three interviewees volunteered that they identified with the LGBTQ+ community.

The majority of interviewees were currently working in the United States ($n = 15$), including states in the northeast, midwest, south, and west; one interviewee was working in Canada and another in the United Kingdom. They reported a wide array of disciplines (see Table 1) and had worked in science or STEM-related fields between 8 and 30 years ($M = 20.0$, $SD = 6.3$). Fourteen identified as currently or formerly affiliated with academia, six identified as currently or formerly affiliated with STEM industries or media, and four identified with both academia and industry or media. Seven identified their work as specifically related to issues of diversity within academia or STEM industries (e.g., diversifying the pipeline regarding gender or race, investing in ventures launched by people from underrepresented groups, or working with mental health organizations).

They also reported a variety of interactions with media professionals: 23.5% reported having between 1 and 5 interactions; 23.5% reported having between 5 and 15 interactions; 29.4% reported having between 15 and 50 interactions; 23.5% reported having more than 50 interactions. Media outlets varied widely and included traditional/legacy local, national (e.g., NPR, ABC News, *Boston Globe*, *New York Times*, *The Atlantic*, *TIME Magazine*) and international outlets (e.g., BBC, CBC, Australian Broadcasting Corporation, German press), as well as newer digital outlets (e.g., Huffington Post, The Conversation) and user-generated content including podcasts. Interviewees also described engaging with university communications specialists and outlets targeting science-oriented audiences (*Wired, Scientific American, Computer World*).

TABLE 1 Study 1 interviewee demographics.

Subject #	Age	Race/ethnicity	General area of expertise	Years in field	Number of interactions with media professionals
S01	42	Black	Engineering	24	15–25
S02	68	White	Community research	25	25–50
S03	57	White	Public health	30	More than 50
S04	29	White, European	Chemistry	8	1–5
S05	47	White	Psychology	25	5–15
S06	68	White	Communications	15	1–5
S07	58	White	Physiology	30	1–5
S08	41	White, Mexican descent	Physics	20	More than 50
S09	50	White	Geoscience	25	5–15
S10	41	White, Jewish	Information technology	20	more than 50
S11	50	White	Communications	25	25–50
S12	47	Asian, Chinese	Entrepreneurship	12	15–25
S13	38	White	Biology, communications	15	1–5
S14	41	White	Communications	16	More than 50
S15	46	Black, Native American	Biology	18	5–15
S16	46	White	Engineering	20	15–25
S17	34	Black	Engineering	12	5–15

Interviews took between 30 and 45 min and were conducted *via* video conferencing (e.g., Zoom, Microsoft Teams) or *via* phone. The informed consent form was read to all interviewees. After consenting to participate and have the conversation recorded for transcription purposes, interviewees answered questions about their overall experiences engaging with media professionals in addition to specific questions regarding their projects that received media attention, the subsequent interactions, the resulting media artifacts, and how gender (among other social categories) impacted these experiences. Finally, interviewees shared their advice for future engagements with media producers.

Emergent themes

There were a handful of stories regarding professionals working in entertainment and a sizable segment of stories of people working in digital platforms (e.g., podcasts, blogs), but the majority of the stories shared across the interviews involved professionals working in journalism, including print, broadcast, and digital. Interviewees recognized that their experiences with media professionals were disproportionately in the area of journalism, but connected these stories to claims about the media industry at large. It is important to note that the current themes are drawn from stories about the interviewees' own experiences, but anecdotes about friends and colleagues were frequently mentioned for context.

Media professionals are mostly professional, but unprofessional professionals are memorable

Overall, interviewees reported positive interactions with media professionals. Many expressed that this was surprising because there was a pervasive stereotype among STEM practitioners that media were "evil," that they were not interested in accurately reporting the science and that they were often intent on sensationalizing an agenda with a "soundbite" that could come back to haunt a scientist's career. This attitude manifested through multiple channels, including implicit public discourse and explicit statements made by other people in STEM fields.

"I was brainwashed that media was the enemy… I thought that media was something to be avoided - they would get it wrong." (S02)

"The attitude [in grad school] was 'don't talk to the media or the public."' (S09)

The stereotype that media professionals were ill intentioned and should be avoided dovetailed ironically with the seductive nature of media. Many interviewees were honored to be contacted by and featured in media. The idea that one's work was so novel that the general public would be interested—beyond the esoteric academic or industry communities—was exciting despite the pervasive concern about being misrepresented. However, many shared that their first media encounter was unpleasant, often due to a lack of preparation on the part of the media producers who posed vague questions as well as awkward

studio set ups (e.g., being interviewed by a camera instead of a person).

While interviewees shared largely positive stories, most also reported examples of negative interactions with media professionals who conducted the interview without adequate prior preparation, did not show appropriate consideration for the interviewee, or outright stole their words without attribution. In many of these cases, the final artifacts suffered from this lack of interest or detachment from the subject matter.

"It felt like someone just handed him these questions, he's a videographer, not a reporter. I felt there was nothing. We weren't engaged with each other. He was reading his questions and I was answering." (S07)

Interviewees found themselves in teacher mode, desperately trying to prevent inadvertent misinformation from appearing in the press that could damage their scientific career. Many of the interviewees expressed that they understood that science was complex. They recognized that they had spent years developing a skill set that was impossible to teach to a media professional in a single interview, or to convey to a general audience in one article or news story. However, interviews with scientists who had worked as media professionals shared that this disparity was systemic. One interviewee working in science and health media expressed concern that even people employed in this sector did not understand scientific processes.

"There are few people who really know how the science works. Like the scientific method, how to read a study; how to consider the uncertainty of a result; how to place the evidence from one study in a contextual landscape that makes it make sense… [Instead, they're like] 'This made for a cute headline or this is something that people are going to click on.'" (S14)

This lack of knowledge regarding how science is conducted also extended to their experiences as members of underrepresented groups (including gender and in some cases race). Interviewees were hyperaware of when they or their words may be subjected to stereotypes (by media, colleagues, students, or lay-audiences on the internet). This is beyond the general concerns that were voiced when engaging with media in general. Multiple interviewees mentioned that they were attentive to being "Super careful about words," especially when the work or the discussion pertained to women (e.g., gender pay inequity) or other marginalized groups (e.g., diversifying engineering programs as a racial equity strategy).

Two women of color who worked to diversify tech industries described that they were hyperconscious to avoid the implicit sentiment that their work was "charity" in order to combat the collective assumption that diversifying these industries would be associated with "lower standards." Underrepresented STEM professionals were acutely aware of the unintended consequences of using their words wisely (particularly when discussing diversity and inclusion), for fear that the short distance between audiences and media professionals in the era of social media could make them a target of anonymous trolls.

The pace, processes, and outcomes of science and media are in conflict

The conflicting processes of science and media in the United States were repeatedly mentioned, including the pace of production, the target audiences, and the intended outcomes. STEM fields prioritize looking at the world systematically and methodically to produce empirical evidence to support a hypothesis. The media industry seeks to project the world, and in the United States, as quickly as possible to the largest possible audience. Interviewees were aware that media were fast paced, relied on short and punchy clickbait, and catered to audiences that were not versed in the slow, methodical and repetitious processes that undergird the scientific method to produce verifiable conclusions. Interviewees were very aware of the different expectations of time ("The journalists with deadlines don't send stuff," S05); an hour-long conversation might be distilled to a couple of sentences at best. Nuance essential to the science was discarded due to the design of journalism (e.g., word count, rapid turnover). One interviewee who transitioned from science to media said it simply, "Science is about progress. It's incremental and slow. Editors want to ignore that fact" (S14).

Interviewees also recognized the differences in audience. Scientists train within a given discipline, developing expert knowledge, avoiding statements that are imprecise or unsupported by data, and speaking directly to (and publishing for) other scientists. Media are often targeting lay individuals without extensive training, and instead are trying to convey the most immediate and widely relevant points of decades of research. When discussing the relatively new area of cybersecurity, one interviewee described how reporters struggle with the newness of the discipline; the topic had major implications but there was very little context because bad information is abundant.

"General media usually don't know anything about the topic, they want somebody who can explain like at the very basic level for anybody to understand. Like 'What is this thing? Why do people care?' And they're not digging into the details at all." (S08)

However, in the worst cases, this meant that media professionals were willing to compromise the actual information to get a story or a talking point that fit with their predetermined story arc or agenda ("They're just looking for a good quote" S12). Interviewees understood that media might sensationalize their work in the interest of clicks, taking quotes out of context or using the most simplistic line from an extended description of a complex process, but they often felt "disrespected" or "embarrassed" when these instances happened, and in a few cases, fielded messages from colleagues asking to clarify a quote. In one case, an interviewee's extended explanation debunking fear-mongering language (i.e., "toxic sludge" is not correct when referring to the hazardous water post-hurricane) was edited to make it sound like she herself was using the term she had actively debunked in the longer interview.

This also manifested in conflicting approaches to extrapolation. Interviewees were regularly asked about the implications of their research, but many were hesitant to extrapolate even when pressed by a journalist. They said that they did not want to speak outside of their expertise because it was antithetical to established scientific practices, but also acknowledged how colleagues who were men were willing to embrace the grander implications of their findings, sometimes advancing risky ideas that were not yet proven. One interviewee who had moved from working in a neuroscience lab to working as a journalist explicated socialized gendered disparities.

"I find female scientists to be much more protective and specific and almost rigid about what their research says and what they want to answer and how they want to answer. I find male scientists to be generally more able to brag or bloviate." (S14)

New digital platforms like podcasts, blogs, and vlogs were an important exception to these trends. Many interviewees reported positive experiences with media professionals producing podcasts, as well as digital outlets like theconversation.com, which allowed for longer conversation, clarification, and corrections, all of which are expected in the study of science. Podcasts were more likely to be hosted by someone who had inherent interest in the discipline given the lower barriers to entry and the opportunity for a microtargeted audience. Digital outlets allowed for long stories and had professionals in these platforms time and patience to pursue them. Furthermore, interviewees were willing to engage in conversations about the implications of their work in this format because they were allowed to contextualize and deliberate extensively on the record.

Interviewees recognized the disparities between the processes of science and the processes of media, but this led to less-than-ideal interactions especially among interviewees not trained in engaging with media outlets. Although this resulted in personal frustration for the interviewees in many cases, it also meant an active misrepresentation of the interviewee's words. Some described instances when they felt that their expertise was being used to make a point that the media professional had already decided on. Media professionals who were unaware of or not passionate about the subject matter would formulate their stories based on the best social media post and then search out experts that would "legitimize the angle that they have picked for this story" (S11). These interactions were offensive because the professional was "not making a good faith effort to represent the science correctly" (S08). Even worse, two interviewees described instances where their words were outright plagiarized by journalists, one from a published book another from their personal blog, with little to no repercussion for the offending journalists, both of whom were men. Interviewees also acknowledged that the common experience of media professionals twisting interviewees' words to make a point at the expense of the science was uniquely harmful given the existing stereotypes of women in STEM as less competent.

Despite these frustrations, there was a sentiment that scientists were responsible for engaging with media, and interviewees had one of two reactions (and in some cases both) to this relatively recent component of working in STEM fields: (1) universities and scientific programs needed to do more to prepare scientists to engage with media professionals and (2) the request was beyond the scope of scientists who are already spread thin with their research and teaching. Many interviewees acknowledged that media training should be included as a routine requirement of STEM professional preparation. Interviewees acknowledged how their comfort with the media increased with time and opportunities, and that a little media training went a long way, including everything from staying on message to dealing with unanticipated or "gotcha" questions. However, many also expressed frustration with this expectation because the pace, processes, and expectations of science and media are in conflict. Promoting one's science would take time and energy away from research, causing interviewees to spread themselves too thin because the media industry was shirking this responsibility.

"Make your work more accessible. You need to talk to more people. You need to do this for the kids… And do this in a vacuum when you have no training. It is friggin ridiculous. (S01)

"If I was a man…"

No interviewee reported feeling outright disrespected by media professionals, but every respondent had a story to share that, when read through the lens of gender (as well as issues of race or socioeconomic status), begged the question: Would that have happened if I was a man? These anecdotes ranged from microaggressions to overt aggressive questions or comments that diminished the interviewee's expertise and experiences. The most common microaggression was an assumption that the interviewee was less qualified. These microaggressions occurred with lay people, students, and colleagues, but in the case of media professionals, it had unique implications for the representation of science and specifically women in STEM in public discourse.

One interviewee shared a story of a local reporter who, when covering a prominent engineering alumni event in Silicon Valley, told the dean of the engineering school, "We'll begin when the dean arrives." Another related an awkward interaction with a photographer for a local magazine who instructed her and her co-author (also a woman) to strike a "power pose" while shooting a story on the effects of road salt. Yet another called out a reporter by name that would regularly afford her male colleagues more space in the final artifact about faculty governance despite interviewing all of them for the same amount of time. One interviewee also began to systematically observe her placement in the final artifact when multiple experts were featured.

"I was always last. But maybe that's how they crafted the story. But I was always looking for where I was placed in the article, and how many lines were dedicated to what I said versus someone else. [I was] always at the bottom. Fewer lines and at the bottom." (S17)

Other interactions were more open, but less obvious. One interviewee shared a story of a local television appearance during a presidential election cycle; the first question asked by the woman interviewing her was, "What is your political affiliation?" Although this was not explicitly about gender, the interviewee recounted that she had never seen a man asked such a pointed question at the start of an interview when they were appearing as an expert in political science. The interviewee described how it undermined her status as a non-partisan researcher who works with multiple political parties, a point she explicated to the producer when she rejected a later invitation to be back on the show. She wondered, "What other experts do you do that to? … If I had been a sage white man, would she have asked me the same question?" (S11).

Interviewees also recounted instances where media professionals would insinuate that their gender was the impetus for their work. "How did you get into this work?" implied that they themselves were personally impacted or personally invested in hopes that they would get some salacious detail. One interviewee who had worked on the objectification of breastfeeding and another who investigated sexual assault shared similar observations: asking about one's personal experiences was a "tactic" that also fed into stereotypes of women being more emotional and less logical or intelligent (e.g., questioning women's role in a sexual assault).

"People [want] to know all the ways in which I must have been scorned. What's my personal story instead of just approaching me as an expert. It feels as if there's this assumption that I'm coming at this from a place of lived experience. And not possibly just as an expert who's studied this for years. So that can feel frustrating." (S05)

Similarly, "What's it like to be a woman in STEM?," which multiple interviewees referred to as "The Question" and was often accompanied by "How do we get more girls interested in STEM?," was a touchstone across interviews with women in fields that were historically dominated by men, including chemistry, physics, and engineering. "You're being asked to explain why your minority isn't more prevalent in your line of work. And it's often the minority that gets asked that more often than the majority" (S04). Common among these stories were instances when the interview was scheduled to be about research, and this was snuck in at the end of the conversation.

"It totally throws me sometimes… I was really like in a flow with science and getting there. And then they were suddenly like, 'So there's not a lot of women in physics. What's it like to be a woman in physics?' And then suddenly I'm not talking about physics anymore. Now they want me to perform being oppressed in my field… It feels really disrespectful and definitely makes it harder for me to do the job I came here to do." (S08)

All of the interviewees had fielded this question at some point, but consistently insisted that the best way to have this conversation was when it was the focus, not brought up as a light-hearted afterthought. That approach in itself minimized the gravity of the issue. The question was too big to be answered in a soundbite, but they recognized that media professionals were looking for this short, pithy response.

When interviewees were asked if they observed different trends according of social categories, many shared flippant observations (e.g., young men were more likely to ask "gotcha" questions, older men inevitably asked "The Question" or some derivative of it, younger women were more likely to be working in the area of new technology/social media and were often more prepared) but they often contextualized these observations as potentially stereotypical. Ultimately, interviewees shared stories of being underestimated and misrepresented by both men and women media professionals, indicating that both men and women contributed to negative experiences by the interviewees.

Many also shared observations of men were thriving in the media spotlight. Friends, colleagues, and even students who were men were afforded more media opportunities and therefore quickly developed a professional "brand" as experts. In most cases, they were white men who were conventionally attractive or "looked like experts." One Black woman recounted how, even in her research area of social justice, white men who lacked the lived experience were given more access to media and became the "go-to voice." The pervasiveness of this phenomenon was frustrating and reminded interviewees of the exclusionary environment in which they worked. When taking her children to a museum, one interviewee observed that every expert in every video was an older white man. Another who started and runs her own technology firm with another woman shared that people regularly assumed that she was not the technical lead because she had a traditionally female name; in meetings, technical questions would be directed to the man in the room even though he was not a chief officer of the company.

"It's the power of the beard. It's the power of looking like an IT guy. It's the power of the deep voice. I think it's easier for journalists to quote someone [with a man's name] and have readers really believe that he knows what he's doing than for them to quote me." (S10)

It is important to acknowledge that these negative interactions were from media professionals with whom the interviewees did not have an ongoing relationship and who had contacted them seemingly out of the blue. Gender was less impactful when they were contacted for their expertise, or when the media professional knew that they were engaging with someone who was well-credentialed in the field. In this case, expertise appeared to trump gender but even in cases where they were publicly known as the expert, many felt that they still needed to project the mantle of authority.

Media engagement is an ethical obligation

When asked why they chose to engage with the media around a given project or as an expert, the interviewees' responses were consistent—scientists had an ethical responsibility to communicate their findings to the public, especially in cases where the research had been federally-funded. In the current environment where one-fifth of adults in the United States say that they have no confidence in scientists (Kennedy et al., 2022), several mentioned an imperative to convey the impact of their work and to be held accountable to the public.

Many expressed that they enjoyed talking to media and it felt rewarding when it went well. Overall, they were not turned off by the lack of knowledge in media professionals, and reveled in explaining the problem, the methods, the solution, and the implications. They were also generally willing to talk for much longer than was original planned. One interviewee said that talking to motivated journalists was "like talking to your brightest students" (S09). Interviewees who had engaged with media extensively (i.e., 50 or more interactions) reported that they often found themselves doing extra work ahead of time, including researching the outlet, asking for questions ahead of time if they were not provided (every interviewee said that they appreciated receiving the questions ahead of time), or asking questions of the media professional concerning the target audience (e.g., technical or non-technical, business leadership or general audience). They then adjusted their language accordingly.

"I love helping people connect with science, because everyone interacts with science every day. It's around us. That's what science is. But not everyone is given the opportunity to understand at their level or at their comfort." (S13)

Furthermore, successful media coverage created a snowball effect. One good interview or quote could yield more media requests, allowing the scientist to reach a broader audience and amplify the message. Although advancement in academia and other STEM industries are rhetorically independent of public adoration, media appearances were both subjectively and objectively valuable as increased exposure connected them with policy makers, collaborators, and students. It also gave them the opportunity to correct misperceptions, both related to the science and to the underrepresentation of women in STEM fields. For interviewees whose work was politically controversial, they focused on explaining the problem in a way that encouraged agreement on the facts of the problem. Similarly, questions like "Why aren't there more women in STEM?" although frustrating, allowed interviewees to set the record straight.

"There is this perception that there is a pipeline issue even amongst people who are from [underrepresented] groups. So, I wanted to make sure that people knew that we were not lowering the bar by choosing to work with companies that were founded by underrepresented founders." (S12)

Some interviewees acknowledged that at the same time that there was a push for scientists to be more public about their work, the environment was also more perilous especially for those who are marginalized in STEM. Controversy is good for media outlets—after all, engagement drives views and ad dollars—but controversy can be detrimental for the scientist, especially those that are marginalized, that are earlier in their careers or at greater risk from the toxic behavior of anonymous social media audiences. When writing about hydrogen fuel cells, a reader criticized an interviewee's writing asking, "What does this little lady know about fuel cells?" She denied the request from her editor to respond to the comment, citing her own well-being; "When men get mad they will make it about gender" (S14). In other cases, interviewees shared stories of having to tailor their work and their recruitment efforts to account for social pushback online or from political interests outside of their discipline.

Discussion

Gender did not explicitly play into every question, but there was an undercurrent of gendered socialization in most responses. Although the majority of interviewees' interactions with media professionals were generally positive, they clearly remembered the interactions that were disrespectful and described a spectrum from misrepresentation as an honest mistake from someone not versed in their area all the way to ill-intentioned reporters whose desire for clickbait actively disrespected their work. Furthermore, every interviewee had an anecdote where they were misrepresented or underestimated—by both men and women—and many attributed this to the process of media and pervasive gendered stereotypes, but nonetheless felt that engaging with the media was important and wanted to improve these interactions.

Interviewees expressed frustration with reporters who were unfamiliar with the subject matter given that information is abundant, either pertaining to the research in question or to the interviewee themselves. Interviewees who had transitioned to media confirmed that this was an institutional phenomenon; the expectation of a 24-h news cycle meant that reporters simply did not have the time to dig deep or be functionally knowledgeable about a given subject. This led scientists to be perpetually guarded against media professionals who would twist their words even if the majority of their interactions were positive. They were accustomed to having their expertise questioned and more seasoned interviewees researched the requesting outlet to anticipate the most effective messaging and to protect themselves. The lack of work on the part of the journalist often meant more work on the part of the scientists; this added to the invisible labor already disproportionally fulfilled by women in STEM to protect themselves and improve public discourse

(June, 2015; Social Sciences Feminist Network Research Interest Group, 2017; Ruder et al., 2018).

Practices within scientific publishing and peer-reviewed journals discourage speculation resulting in a paradox that uniquely inhibits women from taking advantage of their status as experts in mainstream media. Women have been socialized against advocating for themselves or "tooting their own horn" whereas men have been conditioned to and even praised for self-promotion (Rudman, 1998; Exley and Kessler, 2022). As several studies have shown, men are more likely to cite their own work in future publications compared to women, a complicated process that enhances their value in a citation-based industry (Chawla, 2016; King et al., 2017; Mishra et al., 2018). Several interviewees explicitly said that they actively avoided speculation when it was asked of them by media professionals, but people who can make grander connections were more likely to be contacted by media professionals in the future, drawing attention to gendered expectations.

In the end, everyone agreed that the bidirectional relationship between scientists and media professionals could be better: media professionals needed time to embrace their scientific curiosity, a rarity in a fast-paced nature of the media industry and scientists needed to be responsible for the media narrative that surrounds them. Although many enjoyed the opportunity to "control the narrative" by explaining their own research to media professionals, science and scientists need to consider media as a partner, not just a means of amplification.

"I think communication is the most important toolkit we have for leading in STEM and making change in STEM, both from the implementation of good science and engineering, but also the recruitment and rebuilding civic trust in higher ed." (S16)

Limitations

The majority of the interviewees self-identified as white (81.3%), higher than the 63% of white women in STEM fields (National Science Foundation, 2015), and almost all were working in the United States. The importance of intersectionality was raised by many of the interviewees of all racial and ethnic backgrounds, but women of color expressed concerns regarding the representations of multiple communities. Future work should seek to diversify these conversations to incorporate women working outside the United States to explore these phenomena in international media. Similarly, focusing on scientists with multiple marginalized identities will offer insight into how one's gender identity intersects with other social categories, including race, socioeconomic class, and ability, to produce unique interactions with media professionals and potential disparities in media content.

The current work describes the experiences of microaggressions and discrimination experienced by women in science in their interactions with journalists, but it is unclear as to how these interactions connect to the overall experience of media professionals and the media industry at large. Furthermore, almost all of the conversations focused on print journalism or print-based media (e.g., web publishing) and non-fiction user-generated long form content (e.g., podcasts). Only a few interviewees shared experiences engaging with media students and professionals who were seeking to create entertainment content (i.e., a treatment for a television show based on a historical figure, a stage play) or advertising. This bias in the interactions with media professionals was not anticipated, but is unsurprising in hindsight: entertainment and advertising sub-areas of the media industry are more likely to have a science consultant (Kirby, 2003), and therefore may be less reliant on reaching out to current working scientists.

Future work must investigate interactions with media professionals working across sub-areas of the media industry with a focus on correlations and patterns within these sub areas to assess how these anecdotes manifest in content trends like the biases in film and television described in the prior literature and the effects of the "scientific appeal" in advertising. Study 2 surveys media professionals to address these gaps in the research and understand how stereotypes of science and women in STEM relate to the work of being a media professional.

Study 2

To address the second research question regarding the trends among media professionals, a survey was conducted to assess if stereotypes about science and scientists correlated with their work as a media professional, and if these relationships varied across sub-areas of the media industry (e.g., journalism, entertainment, social). To assess these differences, we conducted a series of correlations and regressions on subsets of the overall data as well as demographic comparisons within sub-areas but avoided comparisons between industry sub-areas. The survey and data are available *via* Open Science Framework at osf.io/ju3q6.

We define a media professional as "a person who earns income by producing or distributing media content, this includes but is not limited to print, movies, television, radio, interactive, social, journalism, entertainment, and advertising." We acknowledge the differences between sub-areas of the industry—journalism informs audiences, advertising and public relations persuade audiences, and entertainment emotionally activates audiences (Corsbie-Massay, 2016) although each subarea of the industry may draw on components of other subareas (e.g., journalism and advertising that emotionally activates can garner higher ratings and more coverage in the public sphere; Peters, 2011)—but we purposefully deployed a broad definition in order to address the phenomena of producing and distributing messages for a broad audience. In recent years, digital and social media has sought to target

TABLE 2 Study 2 respondent industry sub-areas.

Industry sub areas	*n*	%
Digital content (including journalism: Digital)	77	73.3
Digital content: Social media	51	48.6
Digital content: Interactive interfaces	8	7.6
Digital content: Podcasting	6	5.7
Journalism	37	35.2
Journalism: Print	20	19.0
Journalism: Digital	15	14.3
Journalism: Radio/TV broadcast	13	12.4
Entertainment	40	38.1
Film	18	17.1
Television	17	17.1
Music industry	23	12.9
Advertising or public relations	28	26.7
Photography	22	21.0
Videography	18	17.1

audiences for the same financial reasons, but often through micro targeting specific audiences (Corsbie-Massay, 2021).

Participants

Participants were recruited in July 2022 through Qualtrics Panels. After reading the information sheet, they were asked if they identified as a media professional and to briefly describe why. Participants were considered eligible if they were over 18 years old, located in the United States and identified as a media professional, or Responses were closely reviewed to ensure validity, resulting in a final $N = 105$. Participants reported their engagement with science, as a member of the public and as a media professional, their attitudes about public engagement with science, and their agreement with common scientist stereotypes.

Participants ranged in age from 18 to 69 years ($M = 36.8$, $SD = 11.2$). In an open-ended response to the question of gender, over half of participants (52.4%) identified as female, 45.7% identified as male, and two participants identified as non-binary. Participants then provided their ethnicity in an open-ended format before indicating with which racial categories they identified; 69.5% identified as non-Hispanic white, 27.6% identified with non-white groups (18 identified as Black or of African descent, 4 identified as of Asian descent, 3 identified as of Indigenous descent), and nine identified as Hispanic or Latino. All but one participant was born in the United States. Half of participants (51.4%) reported making <$60,000 annually, on par with the income distribution in the United States (United States Census Bureau, 2021). Alternatively, 58.1% reported having a college degree, with 11.4% reporting an advanced degree. Fifteen participants (14.3%) reported having a STEM degree, but the open-ended responses were varied and included "Arts" and "Communications."

Participants career demographics were diverse. Participants were asked for their current title and how long they had worked in that position. Titles included everything from content creator to CEO and time spent at their current position ranged from one to 38 years ($M = 9.4$, $SD = 8.0$). They then indicated the sub-areas of the industry in which they currently worked (see Table 2); participants selected an average of 2.5 ($SD = 1.9$) sub-areas, with 58.1% of participants identifying with multiple sub-areas. Sub-areas were then aggregated into digital content (73.3%), journalism (35.2%), entertainment (23.8%), and "creative" (39.0%); the final category was determined *via* theory (i.e., media associated with creative endeavors) and factor analysis.

Measures

The Public Engagement with Science (PES) scale (Gu and Feng, 2022) was deployed to assess their interactions with science as a lay person, which included questions regarding activities and attitudes. The activities subscale included eight items assessing respondents' engagement with science information *via* media (e.g., books, television, social media), as well as their participation in conversations and conferences discussing science topics measured on a 5-point Likert scale from strongly disagree to strongly agree (Cronbach $\alpha = 0.845$). The attitudes subscale included four items assessing respondents' attitudes regarding the social effects of their activities measured on a 5-point Likert scale from strongly disagree to strongly agree (Cronbach $\alpha = 0.702$).

Engagement with Science as a Media Professional (ESMP) featured four researcher-developed items adapted from the PES attitudes subscale to assess respondents' attitudes toward public engagement with science as a media professional: (1) As a media professional, I frequently engage with science-related materials. (2) As a media professional, I frequently engage with people who work in science. (3) As a media professional, I frequently create content that relies on scientific information. (4) Scientists frequently engage with the content that I create as a media professional. Participants rated their agreement on a 5-point Likert scale from strongly disagree to strongly agree (Cronbach $\alpha = 0.867$). PES activities, PES attitudes, and ESMP were highly correlated ($rs > 0.6$; see Table 3).

Stereotypes about science and scientists were assessed using Lips (1992), which featured three primary subscales measured on a 5-point Likert scale from strongly disagree to strongly agree where high numbers were associated with stereotypical attitudes regarding scientists. Science-as-demanding was assessed using four items (Cronbach $\alpha = 0.332$), the asocial scientist stereotype was assessed using three items (Cronbach $\alpha = 0.586$), and

TABLE 3 Descriptive statistics and correlations for study 2 variables.

Variable	*M*	*SD*	1	2	3	4	5
PES activity	3.58	0.82	–				
PES attitudes	3.70	0.82	0.725**	-			
ESMP	3.24	1.10	0.741**	0.619**	–		
Incompatibility	2.06	0.83	0.126	0.122	0.273**	–	
Gendered domains [a]	3.72	0.04	0.025	−0.124	−0.174	−0.003	–

[a]An inverse transformation was performed on the composite of domains historically dominated by men.
**p < 0.01.

feasibility of dual roles and compatibility of science career and family life (i.e., incompatibility) was assessed using seven items (Cronbach $\alpha = 0.770$). The first two subscales were not retained in the analysis because they did not achieve reliability.

Gender association of academic disciplines (Smyth and Nosek, 2015) was deployed as a measure of stereotypical associations. Participants were asked to indicate how much they associated academic disciplines with men or women (an adaptation of the original methods that deployed the terms "males" and "females"). Items with low value indicate disciplines associated with men (i.e., Engineering, Math, Physical Sciences; Business; Computer and Information Sciences; Law or Legal Studies), whereas items with higher value indicate disciplines associated with women (i.e., Education; Visual or Performing Arts; Humanities/Liberal Arts; see Figure 1). A factor analysis revealed that disciplines associated with men factored together (Cronbach $\alpha = 0.810$) as did disciplines associated with women (Cronbach $\alpha = 0.545$); the five disciplines between these two clusters (i.e., Social Sciences or History, Biology/Life Sciences, Communications, Psychology, Health or Health-Related Sciences) either factored into a third dimension or did not factor neatly onto the previous two gendered factors. Therefore, only the composite generated by disciplines dominated by men is used as a measure of stereotypical associations.

Results

Preliminary analyses

Given the unique application of these scales to a diverse professional population as well as the low reliability of the stereotype subscales, we sought to replicate the findings from the studies from which the measures were sampled. The Public Engagement in Science assessment drew from a college student sample in China ($N = 8{,}075$) and found a significant difference between PES activities and PES attitudes; respondents reported significantly greater attitudes about public engagement with science compared to their actual activities engaging with science (Gu and Feng, 2022). This finding was replicated in the current dataset: media professionals reported greater attitudes ($M = 3.7$, $SD = 0.8$) than activities ($M = 3.6$, $SD = 0.8$); $t_{(104)} = 2.4$, $p = 0.019$. Alternatively, there were no effects of gender on the stereotypes of science scales, a marked distinction from the original scale published in 1992 (Lips, 1992) using a sample of undergraduate students from a Canadian university ($N = 488$) which found that men rated science as more incompatible for women and reported greater agreement with the asocial scientist stereotype.

Industry-related correlations

The frequency of scientific engagement as a media professional (ESMP) correlated with gender-science incompatibility ($r = 0.273$, $p < 0.01$); respondents who frequently engaged with science as part of their job as a media professional reported greater incompatibility between careers in science and family for women. All correlations are available in Table 3. However, a different story emerged when industry patterns were investigated separately, ESMP was strongly correlated with incompatibility among those working in entertainment ($r = 0.390$, $p = 0.013$, $n = 40$) and advertising/PR ($r = 0.525$, $p = 0.004$, $n = 28$). There was no correlation between engagement with science and stereotypes of science and scientists among those working in journalism, digital media, or social media. Interestingly, working in digital, or social appeared to *inhibit* stereotypical associations: those *not* working in digital or social media reported a correlation between ESMP and incompatibility (outside digital $r = 0.440$, $p = 0.022$, $n = 28$; outside social $r = 0.435$, $p = 0.004$, $n = 45$). Furthermore, respondents who reported only working in one subarea of the industry exhibited a correlation between ESMP and incompatibility ($r = 0.344$, $p = 0.026$, $n = 44$) whereas this correlation was not significant for working in multiple areas of the industry.

Correlations by demographics

Age and experience also affected these relationships. ESMP was correlated with incompatibility for older respondents ($r = 0.401$, $p = 0.004$, $n = 51$) and for respondents who had worked in their current position for longer than 6 years ($r =$

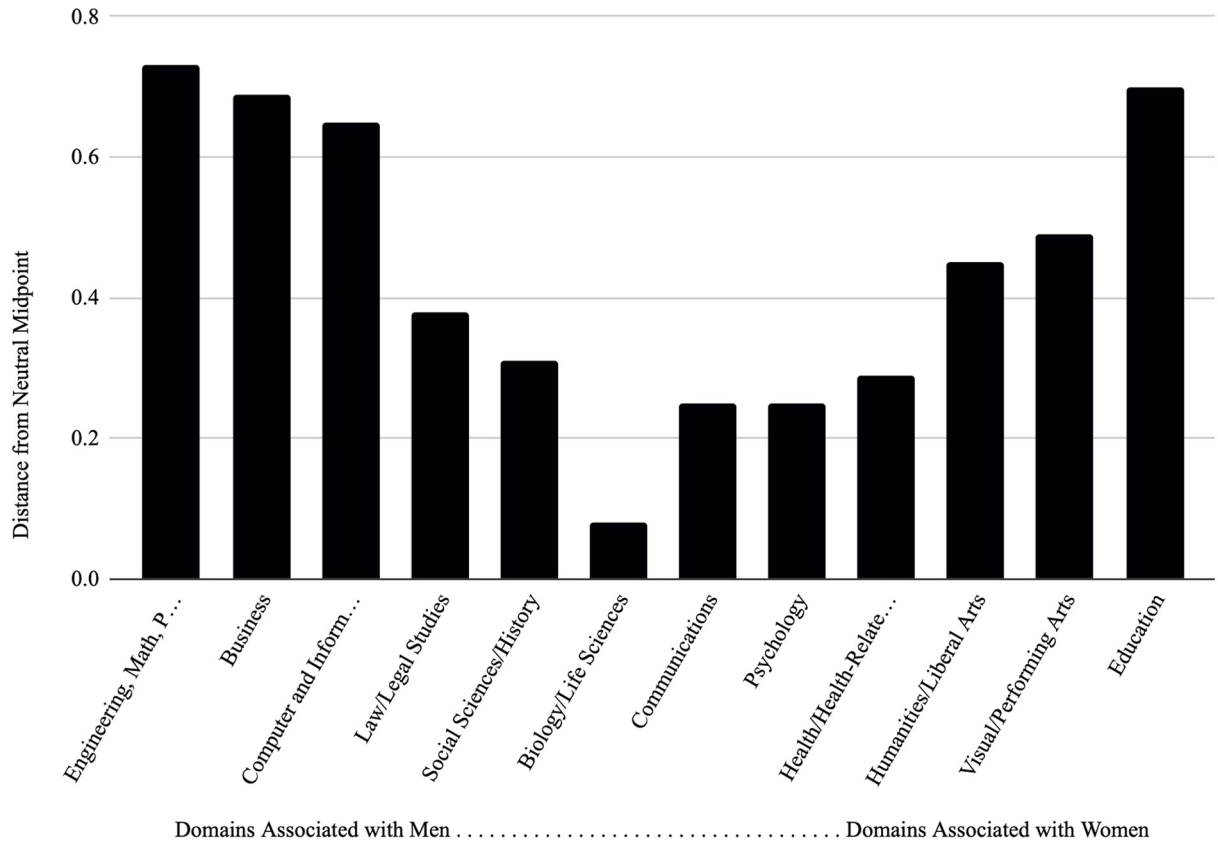

FIGURE 1
Distribution of gendered association of academic disciplines; distance from the neutral midpoint.

TABLE 4 Study 2 mediation analysis: Age, incompatibility, engagement with science as a media professional (ESMP).

	Belief in family-STEM career incompatibility for women				
Variable	**St. β^2**	***R***	**ΔR^2**	***F***	***p***
Step 1: ESMP	0.27	0.27	0.08	8.15	0.005
Step 2: Binary age	−0.13	0.30	0.02	1.73	0.191
	Engagement with science as a media professional (ESMP)				
Variable	**St. β^2**	***R***	**ΔR^2**	***F***	***p***
Step 1: Incompatibility	0.27	0.27	0.08	8.15	0.005
Step 2: Binary age	−0.24	0.36	0.05	6.20	0.014

0.316, $p = 0.031$, $n = 49$). Furthermore, independent samples t-Tests also revealed younger respondents reported greater incompatibility between a career in science and family for women ($M = 2.3$, $SD = 0.7$) and more ESMP ($M = 3.4$, $SD = 1.0$) compared to older respondents [$M_{INCOMPAT} = 1.8$, $SD_{INCOMPAT} = 0.6$, $t_{(103)} = 2.952$, $p = 0.004$; $M_{ESMP} = 3.0$, $SD_{ESMP} = 1.1$, $t_{(103)} = 2.023$, $p = 0.046$]. Stepwise regression analyses reveal that incompatibility mediated the effect of binary age on ESMP (see Table 4); age predicted incompatibility which then predicted ESMP suggesting that they may be actively trying to disrupt stereotypes with their work as media professionals.

Discussion

This initial analysis provides preliminary insight into trends among media professionals regarding their engagement with science and scientists, as well as their agreement with stereotypes of gender and science. Interestingly, media professionals who worked with science as part of their jobs as media professionals reported more stereotypical attitudes regarding the incompatibility of careers in science and family life for women. However, these correlations were not present for people working in the aggregated sub-areas of journalism and digital (including the specific sub-area of social media) or people who indicated that they worked in multiple areas of the industry.

The overall effect may be due to the fact that media professionals who engage with science as part of their work

may attain a more nuanced understanding of the barriers to success that women face in STEM fields. Pursuing a career in science often demands sacrifices in other aspects of life, but the extent to which this is seen as incompatible for men is less prevalent, thereby enhancing gendered disparities by drawing on and reinforcing stereotypes that women belong in the home and not in the lab (Eagly and Steffen, 1984; Tuchman, 2000). However, those working in journalism and digital media may engage with more scientists and more gender diversity compared to entertainment and advertising (Kirby, 2003). Accessing scientists directly through social media may provide more exemplars of different people working in different disciplines. It is also possible that those who work in digital and social media and those who work in a variety of industry-subareas may observe more diverse representations of scientists given the affordances of these platforms.

There were limited differences in the variables of interest by demographic group. Unlike Lips (1992), which found that men reported greater agreement with stereotypes of science and scientists leading them to conclude that men were more susceptible to gender stereotypes compared to women, gender did not exhibit a significant effect on these measures or gendered association of academic domains in the current dataset. However, disparities emerged when assessing differences by age cohort. Younger participants reported greater engagement in science in general and as a media professional, but these constructs were not related. This disparity may be due to expectations of early career media professionals; those working in their current position for 6 years or less also reported greater engagement with science in general and as a media professional. More interestingly, younger participants (34 years and younger) reported greater stereotypical beliefs (i.e., incompatibility) compared to older participants (35 years and older). Similarly, the correlations between ESMP and incompatibility were pronounced in respondents who were 35 years of age and older and those who had worked in their current position for more than 6 years, indicating generational differences. It is clear that these stereotypes have not been eliminated but instead no longer differ by gender.

Despite concerted efforts targeting young people—and especially young women—to pursue careers in science, younger people continued to believe that a career in science was incompatible with a family for women. As described earlier, content analyses of women in science in entertainment content (specifically television and film) as well as user generated content reveals a consensus narrative wherein women cannot have both and that they are expected to give up a family in order to pursue a career in science or vice versa, thereby reinforcing this incompatibility. Notably, there was no effect of age or time in current position on gender associations of academic domains.

Limitations

The current dataset provides a valuable overview of potential patterns across a wide variety of media sub-areas, but additional respondents are essential to clarify and affirm the emerging patterns. The number of respondents was not sufficient to make claims regarding sub-areas of the media industry (e.g., print vs. broadcast vs. digital journalism, movies vs. television vs. streaming in entertainment). In addition, the sample featured people working in the United States; future work should seek for greater diversity within the media industry and globally to better understand how patterns emerge.

Furthermore, it is unclear as to whether greater engagement with science as a media professional causes greater agreement with stereotypes or if greater agreement with stereotypes causes greater engagement. The conflict between family and a career in STEM for women are rooted in longstanding trends may become more apparent as media professionals engage with science and scientists. Alternatively, a belief in this trope may lead media professionals to engage more closely with science as part of their career, possibly to debunk these stereotypes for themselves, as was the case with age, stereotypes, and ESMP: younger media professionals reported greater stereotypes which in turn resulted in greater engagement with science as a media professional.

Most importantly, it is unclear as to how these stereotypes affect the content that the professionals produce. Future research should interview media professionals to ascertain how their stereotypes affect their decision-making regarding writing, recording, editing, and producing messages about science, scientists, and women in science. Counterintuitively, media professionals with high stereotype agreement may be more likely to create content that disrupts these stereotypes if they are self-aware and recognize their role in promoting gender equity among STEM professionals, which is what the regression regarding age suggests.

It is clear that the institutional structure of the media industry impacts representations of women scientists. Journalists are more likely to rely on social media to access experts, causing them to see scientists with more diverse demographics even if they may not migrate into their final stories. There was no measure of the media professional active or explicit ideology that representations of science/STEM should be diversified. Future work should explore the representations of scientists that are present in these areas of media.

General discussion

The current research demonstrates that media professionals play an important role in disrupting stereotypes about women in STEM fields and diversifying the knowledge economy, especially given most Americans get their science news from general outlets (Funk et al., 2017). The process of communicating scientists as individuated and women in science as an inherently

diverse group is one that even media professionals working in science communications may not necessarily be equipped to address as indicated in both studies. The current work is not exhaustive, nor should the findings be seen as the sum of the two studies, but rather we lay the groundwork for understanding how mediated stereotypes of women in science are produced and maintained instead of simply taking the stereotypes as a perpetual given. Disrupting these norms requires a robust understanding of underrepresented scientists as individuals, not just scientists who happen to be women.

Across both studies, both men and women suffer from and perpetuate discriminatory discourse about science and women in STEM fields. In Study 1, both men and women media professionals featured prominently in interviewees' anecdotes of problematic trends. In Study 2, no significant gender differences emerged in agreement with stereotypes, a marked change from the original study 30 years prior, and in juxtaposition with the common belief that simply having more women in a given industry will suddenly correct decades of underrepresentation. Research regarding representation of women in historically dominated disciplines indicates that there is a "critical mass" (Malcom and Malcom-Piqueux, 2013) of about 30-35% that, when achieved, is associated with a communication and cultural shift to greater gender inclusivity. However, this trend does not account for the role of external factors like media discourse in achieving a critical mass or ensuring inclusivity.

It is important to note that the findings from both studies are implicitly and explicitly rooted in mostly American experiences, with science fields in the United States and United States-based media. Gendered stereotypes of science are present globally and changing at disparate rates (Miller et al., 2015), but the disproportionate emphasis on for-profit media in the United States encourages stereotypical representations as a means of attracting audiences and advertisers (Nielsen, 2019), and despite the best of intentions, media professionals are ultimately beholden to the industry and audiences to retain their position as media professionals (Carpenter et al., 2016). The current work is relevant in a global media marketplace, but should not be generalized to other nations' specific media economies.

The role of media in the disruption of gender norms and the advancement of women in STEM cannot be overstated, but it is more complex than simply citing more women as STEM experts in journalism and telling more stories about women in STEM in television and film. The complex nature of microaggressions mean that stereotypes can still be perpetuated despite overt efforts and the best of intentions. A desire for sensationalism may inadvertently misrepresent scientific claims that can hurt scientists' future careers regardless of gender but hunting for a good quote that speculates about the implications of research can actively frustrate or deter women from engaging with media, creating a cycle that limits representation.

Sadly, women who persist in STEM are still considered an anomaly. Depending on their discipline, they are an explicit minority, therefore simply interviewing them becomes an opportunity to discuss more than the intended subject matter. Given the domestic and familial expectations of women in the United States, the fact that they have succeeded in STEM against the odds is a story unto itself that may result in clicks. Publicly available profiles of scientists often simplify the female experience in science by overemphasizing the gender-specific challenges associated with being a woman in science (Mitchell and McKinnon, 2019).

Most importantly, not all media professions exhibit the same stereotypes. Newer digital media options that are free of the traditional media industry expectations, including the limiting structure of time and the overarching demand for large audiences (Corsbie-Massay, 2021), can embrace longer discussions that are more in tune with the processes of science. This was evident in interviewees' excitement about podcasts in Study 1 and the lack of relationship between engagement with science as a media professional and stereotypes for those working in social and digital media in Study 2. However, these disparities beg the question: How can we better tell the stories of women scientists as communication scholars and communicators?

Future work: Media need science and science needs media

Patching the leaky STEM pipeline requires a multipronged approach. The onus of improving representation of women lies primarily in the STEM culture which has historically created a "chilly" climate that is not conducive to success for women and other underrepresented minorities. The STEM fields operate in a broader communication climate where media professionals have perpetuated stereotypes against women in STEM, contributing to the status quo. This research study demonstrates that STEM women need to hone their communications toolkit while media professionals need to work harder to disrupt the stereotypes around belonging in STEM that have further contributed to the leaky pipeline.

The division between higher education, government and community is fundamentally a communication proposition. Recruiting and retaining STEM talent requires communicating the value of STEM every day. The lack of communication skills/toolkit is hurting the STEM community because we are not engaging with the media well. STEM fields should invest in preparing scientists to communicate with media. This is particularly important for women and others underrepresented in STEM fields whose voices and lived experiences need to be articulated in order to inspire others to continue in their STEM journey.

But in the same vein, educators of media professionals need to commit to helping media producers to be better educated about the value of science and the best approaches for producing STEM content so that STEM practitioners are less alienated by quotes that misrepresent important scientific concepts. Media professionals need to work to overcome their implicit biases about stereotypes for belonging in STEM. United States competitiveness is reliant on the knowledge economy which is heavily STEM dependent. It therefore behooves schools of public communications to better prepare diverse media producers with solid understanding of science, and how science is conducted so that they are better prepared to engage with STEM practitioners and so that they acknowledge their implicit biases concerning belonging in STEM. "In order to improve diversity of citations and amplify the work of under-represented groups, we have to see the scientist as a whole human, not just a name or a set of publications" (Corsbie-Massay quoted in Desai et al., 2021). Media professionals are a key factor in perpetuating *and* disrupting gender inequity in STEM.

Future research must focus on interventions in media education—the representation of science and scientists cannot be left solely to people interested in science. Media professionals directly and indirectly contribute to the leaky pipeline by reinforcing a broader communications climate that perpetuates exclusionary stereotypes within science that impact everyone, from students, parents, and teachers, to departmental tenure committees, grant-funding organizations, and investors. The intersectionality of science and STEM should be incorporated as communications fields grapple with issues of gender and racial diversity to prepare the next generation of communicators.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://osf.io/ju3q6/?view_only=8aca293c53e94a71a390a320f537071a.

Ethics statement

The studies involving human participants were reviewed and approved by Syracuse University Office of Research Integrity and Protections. The Ethics Committee waived the requirement of written informed consent for participation.

Author contributions

Study conception and design and draft manuscript preparation: CC-M and MW. Data collection and analysis and interpretation of results: CC-M. Both authors reviewed the results and approved the final version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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