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Challenging the stereotype through humor? Comic female scientists in animated TV series for young audiences

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Stereotypical representations about what scientists do, look like, and how they behave are cognized in early childhood and refined throughout life, through direct or indirect contact with the STEM communication climate, whether it be direct interactions with scientists, science education, communique, or entertainment. Popular media (TV) plays an important role in influencing our ideas of science by constructing images of social science reality. What has rarely been discussed in these contexts is what kind of scientific stereotypes are reinforced or challenged in popular TV shows for young audiences, particularly regarding female scientists. Using qualitative textual analysis, this paper examines how female scientists are portrayed through humor (and what kind of humor) in two popular animated entertainment series for children—*Spongebob Squarepants* and *Adventure Time*—and how their portrayal reinforces or challenges gender stereotypes in cultural representations of science. The analysis revealed that science was portrayed as humorously framed non-science, often represented by exaggerated ever-computing datasets on larger-than-life computer screens that would rival NASA. However, the representation of the female scientists in these animated TV comedies was steeped in archaic stereotypes that, surprisingly, were barely associated with humor: it was the science, not the female scientist *per se*, that was comic. Interpreting these findings in light of science communication research, gender studies, popular entertainment studies and humor studies, this article adds new perspectives to our understanding of humor in science narratives and the public imagination, and provides new insights for the study of the intangible aspects of science in culture.

KEYWORDS

women in STEM, scientist stereotypes, gender, *Adventure Time*, *Spongebob Squarepants*, animated TV series, humor, children's humor

1. Introduction

Popular culture is where collective science understandings are created. Indeed, science and entertainment are two of the most powerful cultural institutions we have developed to explore, comprehend and shape our world (Kirby, 2017). Pop culture influences public perceptions about and attitudes toward science by forming, cultivating or reinforcing the cultural meanings of science (Hüppauf and Weingart, 2007). Popular culture in the form of popular media also fundamentally contributes to our collective understanding of what a scientist "looks" like, including their gender. Although representations, and stereotypes, of female scientists have diversified in recent years, there is still a lack of research of such stereotypes in entertainment media for young audiences. What kind of stereotypes, then, is popular television portraying, reinforcing or challenging about science and the people who do it for a career? Perpetuating female scientist stereotypes can hinder public understanding of who—and what—science is for, and may create barriers for young girls to realize their scientific potential and aspirations (Betz and Sekaquaptewa, 2012). It thus matters to explore these stereotypes as the pigeonholing of the female scientist character in popular media has potentially damaging effects; ignoring heterogeneous female characters or "unidimensionalizing" is a form of what Tuchman (2000) calls *symbolic annihilation*—or the absence of representation and character depth. Symbolic annihilation permits media the power to shape public understanding of women in science whilst minimizing their specific and crucial roles. Women are known to experience obstacles to participation and progression in science careers (O'Connor et al., 2018), with cultural stereotypes as just one of a suite of factors impacting how women perform and are perceived in the workplace.

In popular media for young audiences—including animated TV series—it is notable that female scientists are associated with and characterized by humor. Although it is known that humor is a powerful tool for science communication (e.g., Riesch, 2015; Osnes et al., 2019; Carroll-Monteil, 2022) and there is also a growing interest in science comedy, stand-up shows and science-based sitcoms, the role of humor in shaping the stereotype of the female scientist has hardly been discussed in the literature. Against this backdrop, we query: how are female scientists portrayed through humor in television for young audiences, and how does their portrayal reinforce or challenge gender norms in cultural representations of science? We will examine this question by looking at two popular animated entertainment TV comedies for children: *Spongebob Squarepants* (1999–present) and *Adventure Time* (2010–2018, 2020).

Previous research observed *Spongebob Squarepants* through feminist analysis and young girls' self-identification with gender roles (Duvall, 2010), and explored the series' influence on children's preferences for purchasing (de Droog et al., 2010) and food consumption (Piatti-Farnell, 2015). Other studies on Spongebob focused on masculinity, the male gender and queer coding (Dennis, 2003; de Medeiros and de Medeiros, 2018); the influence on pop culture (Groening, 2011; Fuller, 2019), its marketability (Rice, 2009) and its normalization of neo-colonialism (Barker, 2019). Previous research on *Adventure Time* includes a feminist analysis on gender and queer theory (Jane, 2015). An edited collection, *Adventure Time and Philosophy: The Handbook for Heroes* by Michaud (2015), touches on science (relating the show to philosophical texts) inclusive of the protagonist's reliance on science within the series. However, none of the prior research directly addresses the implications of the female science character's scientific career on her personality, her role as a scientist, or the potential social implications these characters have on young audiences, especially in relation to attitudes toward science. There is research on gender and queer spaces, but the relationship between humor and science in these two comedy programmes has hardly been discussed. Against this background, our paper conducted a qualitative thematic analysis on female scientist characters through a close reading of *Spongebob Squarepants* and *Adventure Time* through the lens of Flicker's (2003) seminal research paper, extrapolating archetypes of fictional female scientists, O'Connor et al.'s (2018) discussion of femininity in the scientific workplace, and a humor typology published by Buijzen and Valkenburg (2004). In this study, we analyzed 15 of 248 episodes of the TV series *Spongebob Squarepants* and 19 of 283 episodes of *Adventure Time* to better understand the use of humor to communicate and counter social conventions about science and gender. We discovered that it was not the female scientists themselves, but science—its visual representation and processes—that was associated with various types of humor. We also found that the female scientists studied, although complex characters, both conform to and refute traditional feminine stereotypes.

Historically, comic performance—one of many cultural expressions of humor—has been a privilege of men (see Lockyer, 2011, 2020; Dickinson et al., 2014; Jürgens et al., 2021b). Women have been marginalized in the production and consumption of public humor (Fox, 2017; Jürgens, 2021), while men were believed to have superior humorous expression (Dickinson et al., 2014; Johnston, 2014). Only recently has the scholarly study of comedy and humor begun to acknowledge and historicize women's contributions to comedy in light of the rebellious nature of humor, which allows comedies to shape, if not challenge, social and cultural norms (Mackie, 1990). As women have historically been marginalized in both comedies and TV portrayals of science, a better understanding of their representation and dynamics in contemporary popular entertainment may be relevant to young women's engagement in scientific subjects (see Kirby, 2017). In fact, reflecting

or interpreting the dominant social values of society, media representations of women associated with scientific spaces—including representations of comic female scientists—have the power to directly influence the uptake of such careers by young women (Steinke et al., 2012; Fogg-Rogers and Hobbs, 2019).

Drawing from science communication, popular entertainment studies and humor studies, this paper clarifies the ways that portrayals of female scientists participate in, and contribute to, science in culture by challenging the stereotype discourse. Elucidating the functions and diverse modes of humor (Meyer, 2000) in science-oriented animated shows opens up new perspectives for our understanding of humor in science narratives and the public imagination, if not the cultural power of science, providing new insights for the study of the intangible aspects of science in culture (Burns et al., 2003).

2. Context and background

Media culture has been called "the dominant culture today" (Kellner, 2020, p. 15) and "the primary educational force in regulating the meanings, values, and tastes that legitimate particular subject positions" (Giroux, 2010, p. 2). Media culture shapes our daily lives, identity and opinions, "educating us how to behave and what to think, feel, believe, fear, and desire—and what not to" (Kellner, 2020, p. 2). Depictions of science in popular media and entertainment can significantly influence public attitudes toward science by forming, cultivating or reinforcing the cultural meanings of science (see e.g., Kirby, 2017). Representations of scientists in movies, literature, art and comics (among other media) communicate and produce images of science; they "explore and exploit the mirror images of science or scientists in the collective imagination" (Hüppauf and Weingart, 2007, p. 6). Therefore, popular culture is a versatile frame for interpreting our relationship with science, and pop cultural products—including animated TV series—are vehicles of science communication. Mayumi et al. (2005) argue that popular films not only have the potential to reach a wide audience, but also play an important educational role. It is well-known that films, as a narrative entertainment medium, promote the acquisition of knowledge about science as they can uniquely dramatize, emotionalize, personalize and fictionalize knowledge, which, in turn, can increase understanding, interest and engagement (Dahlstrom and Ritland, 2012). Science in film and television can prompt us to "move beyond simplistic notions of science as merely a collection of facts in a textbook and to consider science as a larger cultural institution" (Davies et al., 2019, p. 8).

While the media, which plays an essential role in constructing science's meaning, take more liberties in constructing images of reality, their frame of reference still remains more or less social reality, which is why the "pictures, stereotypes, and myths of science and scientific work that they transport are all culturally anchored" (Flicker, 2008, p. 242, see also p. 241). Filmic representations of science's procedures and processes produce and present "an image of science" that may not always have much in common with everyday science (Kirby, 2011, p. 117). Science in film is considered a tool for dramaturgy and "for tapping into the creative and speculative aspects of scientific thought" (Kirby, 2011, p. 9), and not a platform for scientific accuracy. Rather, it is a means of conveying a sense of scientific authenticity, and can serve as the content and setting of visually interesting and dramatic scenes that have a logical explanation or contain "scientific sincerity" (Kirby, 2011, p. 68, 12, 17). Within this context, however, there has been little discussion of the role of humor in shaping, if not defining, the cultural representation—or cultural meanings—of the scientist character, although interest in the use of humor in and for communicating science and in science comedy has gained momentum in recent years (e.g., Pinto et al., 2015; Simis-Wilkinson et al., 2018; Boykoff and Osnes, 2019; Cacciatore et al., 2020; Kaltenbacher and Drews, 2020). While exploring the role of humor in engaging audiences around scientific information and science-based issues, these and many other studies (e.g., Yeo et al., 2020) do not consider the relevance of broader cultural narratives of science. This is surprising because humor is a powerful tool in communication.

2.1. Humor, children's humor, and science communication

Over the last few centuries, numerous theories have been proposed to explain what humor is and how it can be defined. The most salient humor theories are relief theory (which argues that humor is a means of relieving tension, e.g., in the form of nervous energy, by expressing ideas that are inappropriate in serious discourse), superiority theory (which interprets humor as an expression of the triumph and superiority of the person exercising the humor over their target) and incongruity theory (which encompasses a variety of theories that relate the humorous effect to the unexpected or surprising ending of a humorous text that is nevertheless consistent with its structure; Meyer, 2000; Morreall, 2020). Although there seems to be no consensus on which of these three theories of humor is most viable (Buijzen and Valkenburg, 2004), most forms of humor seem to disrupt our understanding of the social structure around us or violate "our conceptual patterns" (Loizou, 2008, p. 189).

One of the main features that make contemporary humor so attractive is its transmedial visuality and entertainment value (Jürgens et al., 2021b). Humorous pop cultural products exploring environmental themes, for instance, provide enjoyment and other affective responses and experiences (such as amusement) in relation to the science or environmental issues

at stake, and can thus form, reform or confirm environment-related opinions (Burns et al., 2003). Humor can "influence how meanings course through the veins of our social body" (Boykoff and Osnes, 2019). Meyer (2000), for example, discusses how humor as a rhetorical device delineates group identity and negotiates social norms by outlining four communicative functions of humor: identification, clarification, assertion, and differentiation. Each function has the potential to connect and/or separate communicators and audiences, and can overlap or be attributed differently to humor depending on individual perspectives. Humor is an effective tool to transmit not only the content of a message, but also the values and social identities embedded in it (Lockyer and Pickering, 2008) inclusive of social roles and hierarchy. However, one of the complex subtleties of humor that has been highlighted throughout the research (e.g., by Bore and Reid, 2014) is that humor is subjective: humorous utterances often allow for multiple and even conflicting interpretations, and humor can be an expression of both positive and negative feelings. It can promote positive engagement with science, but only if it is perceived as funny. The choice of one particular interpretation over another depends on both the general cultural context and the particular circumstances of a communicative event (Pickering and Lockyer, 2005). Positive engagement with science may thus not occur immediately after exposure to humor, but humorous messages may influence people's attitudes for longer than serious messages (Nabi et al., 2007).

Important studies by O'Neill and Nicholson-Cole (2009), Moser (2010), Bangsund (2018) and Kaltenbacher and Drews (2020), among others, examine the role of humor and its many expressions, including comedy, in communicating scientific information to the public. Humor has been shown to increase attention to communication and recall of its content (Riesch, 2015), as well as the appeal and perceived legitimacy of the source of the message. Research highlights that humor can draw attention to and increase interest in and engagement with science and science-related or environmental issues (e.g., Anderson and Becker, 2018). Humor can evoke positive emotions including joy (in the producer and the receiver). Joy feeds hope, and hope is essential for sustainable action (Osnes et al., 2019). Paradoxically, despite being such an attractive communication tool, humor may also divert attention from a message (Moret-Soler et al., 2021) and negatively influence the credibility of serious issues (Pinto and Riesch, 2017); it can reduce fear and risk perception, and dilute audience desire to take action (Skurka et al., 2018).

Although humor is produced and consumed not only by adults but also by children, the link between science, humor and children is underrepresented in the literature, even though educational connections have been made. Researchers (e.g., Hobday-Kusch and McVittie, 2002; Rule and Auge, 2005; Semrud-Clikeman and Glass, 2010; Özdemir, 2016) have found a benefit of humor use in the classroom and educational settings—leading to greater comprehension outcomes. Research shows that different forms of humor are perceived and utilized by children at different developmental stages (McGhee, 1988; Bergen, 2021) from birth to teen hood and tandemly coincide with developmental cognition (Neely et al., 2012). Children's humor differs marginally from that of adults and although simpler than adult humor, can be quite varied; from clowning humor, to non-sense humor (Bariaud, 1989), to absurd humor (Buijzen and Valkenburg, 2004), with most humor produced and received by children falling under the incongruity humor theory (Loizou, 2006). Humor is essential for social conditioning and interaction (Semrud-Clikeman and Glass, 2010) and acts as "social lubrication" (Morreall, 1991) requiring abstract thought, memory, and knowledge of the world (Lyon, 2006). Humor is critical for maximizing not only children's social cognition (McGhee, 2002) and connectedness (Stenius et al., 2022) but also to enhance language and communication development (Vrticka et al., 2013), emotional growth, and brain processes such as creating a unique personality (Mayseless and Reiss, 2021; Stenius et al., 2022).

Humor, according to Valkenburg and Janssen (1999), is one of the vital characteristics that children value in their media consumption. Pathmanathan (2014) found that both pedagogical and entertainment media that utilizes humor concretizes knowledge. Since humor is inherent in children's media (Heise, 2014), viewers perceive it naturally and often do not focus on it while consuming the media. For our investigation of comedic portrayals of female scientists in animated TV shows we drew from a humor typology published by Buijzen and Valkenburg (2004), which synthesized and clarified many of the approaches mentioned above. Buijzen and Valkenburg (2004) analyzed the content of 319 humorous television commercials to investigate whether and how humor techniques are grouped into humor categories and exactly which humor techniques and categories characterize their audiovisual medium (aimed at viewers of different age groups, including young audiences). The application of this framework helps to understand the implications of particular humor techniques in cultural products addressing certain age groups. Adopting the Buijzen and Valkenburg (2004) approach to the medium of television shows, we identified humor techniques that have not been explored in Buijzen and Valkenburg's typology.

2.2. Young audiences and media: Children and (portrayals of) science

Visual media is, by its very nature, a particularly accessible medium of communication, as even written and linguistic language is interpreted into visual images in the brain (Hüppauf and Weingart, 2007). Developing minds are more yielding to visual stimuli than adults (Kaul et al., 2020) hence why

animated television shows for young audiences are easily comprehensible with high contrast color palettes (DeLong et al., 2012; Brunick and Cutting, 2014), short, slow paced episodes (Lillard and Peterson, 2011), and often contain captivating audio (Calvert, 2013). However, children's critical evaluation skills are inchoate and thus they are more likely to accept what they see on the screen as true (Harriger et al., 2021). This uninhibited acceptance grows from developmental understanding of object permanence in the formative years of brain cognition/development—forming a mental representation of society based on what is perceived. Animated television aimed at young audiences indeed has a "marked impact" (Pillar, 2011, p. 70) on developing minds and thus entertainment media can be a means of informal educational learning (Pathmanathan, 2014).

Popular animated shows have the ability to be both entertaining and educational, because emotional and/or humorous connections that they often employ to entertain audiences also support learning (Pathmanathan, 2014; Sambrani et al., 2014) and memory reinforcement (Gibb, 2007). Although the evidence of the use of humorous animated television as a pedagogical tool is unclear at present, with studies pointing to risks associated with the use of humors comics and illustrated cartoons in the classroom (Strong, 2013; Sambrani et al., 2014), further research is necessary to understand the impact of entertainment media as a pedagogical tool. Entertainment media for children has the potential to be an underutilized locus in which subconscious exploratory and educational knowledge transfer occurs—with increased research indicating that children are active "explorers" rather than "passive recipients" (Valkenburg and Janssen, 1999) whilst consuming entertainment programs. Pathmanathan (2014) study found that after viewing entertainment media, children showed a greater appreciation for science and the natural world. In fact, Özdemir (2016) suggests that the connection of science and humor may increase children's interest in and enjoyment of science outside of the classroom—which may lead to more students believing that science is "for them." Thus, this demographic is an essential group for burgeoning research due to the strong malleability of young audience's minds and identity by external forces (Pinkard et al., 2017) including, in part by, entertainment media, and can illuminate the impact of science communication, place, identity, and the gender binary.

2.3. Women and girls in science and their representation in popular media

In Western culture, femininity has historically been poised as the inversion of masculinity with features and characteristics relating to the female sex including passivism, intuition, submissiveness, nurturance, and subjectiveness (O'Connor et al., 2018). In recent years, both academia and activism have increasingly begun to disentangle sex and gender [see e.g., Acker (1992) for a relatively early perspective on this shift; Welsh (2020) for a more recent review] and regard gender on a spectrum with sex, behavior, and expressions of masculinity and femininity imbricating within one's personhood (e.g., Hyde et al., 2019). Femininity therein is not as much of a bound confine of the female sex or gender. As Aragón and Smith (2008) describe, it is more of "a constellation of multiple interacting elements that coalesce to yield an energy, an essence, or a state of being" that defies gender stereotypes. It is not to be conflated with gender roles: which are defined as socially acceptable forms of social responsibilities (O'Connor et al., 2018). Femininity is, therefore, an essence of feminine energy. This essence can be difficult to translate into visual texts—as the essence is not easily pinpointed. Character development uses stereotypes to translate this essence into a discernable form and thus makes it easier for audiences to identify the role each character plays within a series. Yet femininity (as described in sex-role theory, see O'Connor et al., 2018) is traditionally recognized solely in relation to male power, rendering femininity subordinate to masculinity—that is to say, less valuable to public and professional life (Schippers, 2007; Aragón and Smith, 2008).

Although women are increasingly comprising greater proportions of scientific degree graduates in many Western countries, they are not well-represented in scientific professions (e.g., Sassler et al., 2017), nor in children's television programs as scientist characters (Long et al., 2010). The representation of women in the media—both fictional and non-fictional—informs what society considers to be culturally acceptable positions for women (Steinke, 2005), including their participation in scientific careers. Indeed, studies (e.g., Cheryan et al., 2013b) have shown that media representations of scientists involving gender stereotypes can be a barrier to women entering STEM fields in ways that are not mirrored by their male peers. Media plays a role in gendering certain activities and reinforcing binary gender roles, even for children (Douglas et al., 2022). Past work has shown that animated shows form part of the media landscape that influences children's development of conscious and unconscious gender stereotypes and biases (Thompson and Zerbinos, 1997), providing a good foundation for the present study.

Prior research has shown that women (and, to an even greater extent though with far less literature, gender non-conforming, transgender and non-binary people) have been historically excluded from STEM, and that the impacts of this exclusion have continued into the sector today. Underrepresentation in areas from science leadership (e.g., Buse et al., 2013; Prinsley et al., 2016), to distinguished awards including Nobel Prizes (Lincoln et al., 2012; Cadwalader et al., 2014; Gibney, 2018; Modgil et al., 2018), and perceptions of inferior publications and collaborations (Knobloch-Westerwick et al., 2013), shows women have been overlooked on many facets of academic science. But even in everyday interactions in the

science workplace, women are subject to the "chilly climate" of being made to feel unwelcome in previously male-only or male-dominant spaces with continued systematic exclusion (Britton, 2017). Women have been shown to experience stereotype threat, where they measurably underperform on knowledge tasks that they have previously shown to be capable at, simply as a result of being aware of and internalizing negative messages such as that women are not as good at mathematics as men (Steele, 1997). This pervasive and harmful stereotype persists (Chestnut et al., 2018) despite global data showing that there is no consistent gender performance gap at the school level, suggesting cultural influences seem to play a role (UNESCO, 2015).

Girls, then, are taking on messages that science is not "for" them and growing up to be women who believe they are not the right fit for a science career (Bhatt et al., 2012). Children's ideas of gender roles in science accumulate and are reinforced over time, especially through repeated exposure to role models and other representations of female leaders (Olsson and Martiny, 2018). Archer et al. (2012a) showed that by age 10–11, UK schoolgirls had already made firm decisions about how their interest in science studies interacts with their sense of feminine identity or what Driscoll (2008) and Patel (2019) describe as "girl culture," with many girls rejecting science aspirations in favor of maintaining the status quo and a "girly" self-image. Popular fictional entertainment is just one of the vehicles that delivers this message that science and femininity are incompatible (Bhatt et al., 2012; Steinke, 2017), among others such as the perpetuation of these stereotypes by friends, family and teachers (Olsson and Martiny, 2018; Carlana, 2019). Not all students have equal opportunity to gain early experience of and interest in science in formal and informal settings (Clements et al., 2021). For example, disadvantaged girls and youth from areas with lower socioeconomic status have limited access to opportunities and resources that have the potential to build their capacity and interest in science (Pinkard et al., 2017). Popular media, in these contexts, can be an important vehicle for communicating the idea that women can be scientists, and that scientists can look like them, influencing young women to pursue science (Steinke, 1999; Chimba and Kitzinger, 2010; Steinke et al., 2012; Fogg-Rogers and Hobbs, 2019). Thus, the "Scully Effect"—where female protagonist of *The X-Files*, Dana Scully, was identified as a personal role model and influential figure by many contemporary female scientists (21st Century Fox, 2018)—highlights the power of positive fictional characters in shaping girls' attitudes toward science.

However, the potential of positive, diverse, and nuanced media representations of women in science is often unrealized. Many representations of female scientists are consistent with those of women working in other professions, with traditional gender stereotypes that place a heavy emphasis on femininity and beauty, romantic or interpersonal relations, dependency on men, and family life (Steinke et al., 2012; O'Connor et al., 2018). For example, the domestic duties of female scientists and their challenges in balancing a family and career are still major storylines that are conspicuously absent in male scientists' profiles in popular media (LaFollette, 1990; Mitchell and McKinnon, 2019). In other words, popular media has generally failed to expand or challenge gender stereotypes—or indeed science stereotypes such as the devoted, lone genius—potentially further alienating girls and young women who see science as incompatible with their values (Long et al., 2010). The present study adds to this body of research by interrogating the portrayal of female scientist characters in humorous animated television series aimed at young audiences to understand how the interface between gender, humor and science is presented in this context.

3. Methods—Theoretical and interpretive frameworks

3.1. Television series sample

The two animated television series analyzed in this paper (Table 1) were *Spongebob Squarepants* (Hillenburg, 1999–present) and *Adventure Time* (Leichliter, 2020–2018, 2020). *Spongebob Squarepants* is an animated comedy television series created by marine science educator Stephen Hillenburg, broadcasting 276 episodes over 13 seasons. The series follows the humorous events of Spongebob, a sentient sea sponge and his best friend Patrick, an imbecilic sea star, cantankerous coworker Squidward, avaricious boss Mr. Krabs and audacious female friend Sandy Cheeks—a land squirrel sent to the town of Bikini Bottom to research sea life—who wears an astronaut suit to breathe underwater. Sandy—with her soft brown fur, large bucked teeth and enormous, mascaraed eyelashes—sports a purple, frilled bikini under her space suit which accentuates her defined bust. *Adventure Time* is an animated fantasy television series created for Cartoon Network. In 283 episodes and 10 seasons, the series follows the adventures of Finn the Human and his best friend, Jake the shapeshifting dog, enacting heroic missions to continually save Ooo, their universe. The brilliant Princess Bonnibelle "Bonnie" Bubblegum (PB) is the main love interest of various characters within the show including the main character Finn, the villain Ice King, Marceline the Vampire Queen and a slew of other minor characters. Altruistic PB–whose long and slender body, and equally long hair, is tinged pink from her bubblegum DNA–conducts experiments in her lab to improve the lives of her candy kingdom subjects.

The two shows were chosen for the present study based on four criteria: (1) they were aired between 1999 and 2019 (in English); (2) they were humorous, animated, non-pedagogical television shows made for a young audience (6–13 years or TV-G to TV-PG rating), and (3) they featured a female scientist in a speaking role "doing" science in at least 48% of the series episodes (Table 1). These two shows were chosen from a pool

TABLE 1 Analysis context against inclusion criteria.

	Princess Bubblegum *Adventure Time*	Sandy Cheeks *Spongebob Squarepants*
Genre	Animated children's TV show	Animated children's TV show
Humor involved?	Yes	Yes
Audience age group	6–14 years old	6–11 years old
Air date(s)	1999–present	2010–2018, 2020
Pedagogical or entertainment?	Entertainment	Entertainment
Representation of science?	Yes; general science, laboratory, and chemistry	Yes; general science and laboratory
Screen time of female scientist character throughout show	Appears in 141/283 or 49% of all *Adventure Time* episodes	Appears in 142/248 or 57% of all *Spongebob* episodes
Is the female scientist a main or side character?	One of main 10 characters, not the main protagonist of the show	One of main 10 characters, not the main protagonist of the show
Does she have a speaking role?	Yes	Yes

of all animated television shows and was narrowed down to five shows with female scientist characters, and then selected based on the above criteria. This left only two television shows available for analysis, each of which only had one female scientist character. These two shows were the only ones that fit these criteria. For the purpose of this paper we focused on original TV series (excluding characters and shows adapted from comics and novels) and only analyzed canonical, episodic material excluding shorts, bonus material, and additional "fan" created content. Additionally, within each episode analyzed the female scientist had to be present and perform a scientific function or be within a scientific setting (e.g., a laboratory).

3.2. Textual analysis

This study undertook a qualitative approach, drawing from and referring to science communication research on cultural phenomena, gender studies, cultural studies, and film studies. The analytical tools used to make sense of portrayals of the female scientists came from sociological readings of films and studies "reading the visual" (Schirato and Webb, 2004). Like Schirato and Webb, but focusing on television, we explore visual texts. A text "comes to have meaning by virtue of the signs that make it up, the way those signs are arranged or organized in the text and also, importantly, because of its context," which means "the environment in which a text occurs and communication takes place" (Schirato and Webb, 2004, p. 8). Approaching TV series as texts—which themselves make sense through narrative, "or stories that are organized visually" (Schirato and Webb, 2004, p. 9)—and thus as something we make meaning from—is a standard procedure in cultural research because "whenever we produce an interpretation of something's meaning—a book, television programme, film, magazine, T-shirt or kilt, and piece of furniture or ornament—we treat it as a text" (McKee, 2003). Textual analysis, e.g., in the form of thematic or content analysis, is commonly used to read such texts, which involve paying "close attention to textual details with respect to elements such as setting, characterization, [and] point of view" (Rapaport, 2011, p. 4). Often, close reading concentrates on the dichotomy between what the text literally says and "what can be inferred" (Rapaport, 2011, p. 4). This approach allowed us to discover "deeper themes" in our core material and thus we became "message investigator[s]" (De Castilla, 2017, p. 137). Jensen (1991) describes qualitative textual analysis as an approach by which meaning production can be studied as a process that is contextualized and inextricably linked to broader social and cultural practices. Therefore, analyzing the content, deeper themes and meaning of humorous animated television episodes can provide insight into the prevailing values and stereotypes of female scientists in society.

3.3. Interpretive frameworks

Combining methodological and interpretative approaches introduced by Flicker (2003) and Buijzen and Valkenburg (2004), we analyzed and interpreted our sample material in four steps. Considering the female scientist character's air time, her use of science, her combined use of humor and science, and the type of science used we selected 34 of 531 episodes (15 of 248 episodes of *Spongebob Squarepants* and 19 of 283 episodes of *Adventure Time*) as our core sample. Once the episodes were selected for analysis each episode was examined three times. Following Flicker's seminal model to better understand fictional female scientist characters and their sciences in our study material, the first examination was undertaken to generate comprehension of the show, its themes, nuances and general humor context and to identify major narrative patterns around the science theme, character appearance, personality, and mise en scène (step 1). The first author focused on watching the selected episodes as a child would watch: not taking notes, simply absorbing the content. A random sample of 10% of the episodes were also watched by the second author in this way to validate their inclusion based on humor in a childlike perspective. The second round of watching was conducted as a close reading analyzing our fictional female scientists in terms of the stereotypical characteristics identified by both Flicker (2003)—in fiction—and

O'Connor et al. (2018)—in relation to femininity—to better understand the representation of science, the female scientists' role within their respective canon, their practice of science, their qualifications, and their relation to male characters. Episodes were coded as either depicting feminine traits (1) or not (0) to produce an overview of the frequency with which these stereotypically feminine attributes contributed to the characterization of Sandy and PB. Like Flicker, we were interested in exploring and questioning the "messages and biases of a [text]" (Flicker, 2003, p. 309) embedded in the way it related to the lives of non-fictional scientists (and the authenticity of female scientists), relations of power and authority, problematic themes and appearance of peripheral groups (step 2). Since cultural representations of science reflect and influence public attitudes toward science, as argued above, and since films interact with social discourses as well as with other films, scholars of science communication have indicated that films need to be studied not only in terms of their relation to social reality, but also in relation to the medium of film, its characteristics and genres, practices and artistic dimensions, mutual citations, and in terms of their interaction with other cultural discourses and phenomena creating narrative worlds (Flicker, 2008). In our analysis we followed this lead. The third round of watching concentrated on clarifying the specific humor situation in each episode. Adapting Buijzen and Valkenburg's (2004) inductive approach and humor typology to the medium of film, we identified the types of humor associated with the science theme and its female protagonist, followed by an analysis and interpretation of the ways in which these humor forms shape the fictional science and female scientists (step 3). Buijzen and Valkenburg (2004) identified 41 humor techniques, which they grouped into seven overarching categories: slapstick, clownish humor, surprise, misunderstanding, irony, satire and parody (Buijzen and Valkenburg, 2004, p. 147). Many of them were discovered in our study material, plus additional facets (although published in 2004, this typology continues to be a useful tool, see Yi-Fan Su et al., 2022). Our own humor analysis, guided by their approach, took into account different humor theories, and showed that many humor techniques (such as exaggeration) are not necessarily funny but "must complement one another to generate humor" (Buijzen and Valkenburg, 2004, p. 149). In a final step (step 4) we contrasted our findings with that of Flicker (2003) on female scientists in film to better understand the female scientist stereotype within the frame of humorous children's entertainment media. To compare our findings (with Flicker in particular), we adapted a structured focused comparison (Rauscher, 2014). This strategy is "structured" in that the researchers formulated general questions that reflected the research objective and these questions were asked of each case studied to guide and standardize data collection, allowing for systematic comparison and accumulation of findings across examples. The method is "focused" in that it deals only with certain aspects of the examples (George and Bennett, 2005). This approach allows "limiting the analysis to those aspects and passages that are of interest" (Rauscher, 2014, p. 67) with respect to the representation of female scientists and comparing the material within our specific corpus as well as the topics themselves "on a standardized basis" (p. 82).

4. Analysis, interpretation, and discussion

Our findings are condensed in two parts: the first part focuses on science and humor, the second concentrates on the scientist stereotype, followed by a comparative interim summary. The full dataset is available from the authors upon request. The analysis found several overall themes around science within the two shows including: slapstick violence, funny contrasts, and exaggerated science environments. Themes surrounding feminine stereotypes in science characters were also observed (see Section 3 for an explanation of how we developed these themes), including: the tethered relationship to male characters, the use of intuition rather than rationality while performing science and how the female scientist's physical appearance either conforms to or rejects the stereotypes presented by Flicker (2003) and O'Connor et al. (2018). The interim conclusions reveal that the humor applied to these scientific characters had less to do with femininity and more to do with the science they performed.

4.1. Science and humor in *Adventure Time* and *Spongebob Squarepants*

Humor is a versatile frame for interpreting our relationship with science. Many of the humor techniques in our study examples were among the techniques described in Buijzen and Valkenburg (2004) typology, with the ones that they attribute to media directed toward younger and adolescent audiences (including slapstick and clownish behavior) being among the most prominent ways to create humor in AT and SB. In addition, and in line with research on the medium of animated film, much of the humor of SB in particular arises from the visual and behavioral familiarity of the protagonists' subjective abilities and non-verbal idiosyncrasies, even if these do not strictly correspond to human behavior (see Bergson, 1914; Buijzen and Valkenburg, 2004; Holliday, 2018). In general, animated anthropomorphs "permit the aesthetic exploration, dilution, exaggeration, and satirizing of the machinations of the human condition" (Holliday, 2018, p. 87), and in our examples this also included the condition of science. Our analysis revealed three major discoveries associated with the representation of science through humor in our study samples: science is embedded in and communicated through comic violence (in the form

of physical comedy), science can be observed through funny contrasts, and is, primarily, visually exaggerated chemistry. Our findings also uncovered that science is not explored as a means to better understand the mysteries of life or to solve the riddles of our existence, but always to serve other (or no) purposes—for and with comic effects.

4.1.1. Science between humor and comic violence

Humor and violence have long accompanied our cultural narratives of science. For example, one of the most successful films of Hollywood's silent era—Seastrom (1924) drama *He Who Gets Slapped*—depicts a scientist who becomes a clown after betrayal by his sponsor and humiliation by the Academy of the Sciences. His clown act involves presenting scientific findings in front of the Academy, and features him getting slapped every evening by other clowns/Academy members. The clown-scientist connection shapes humorous interpretations of *Frankenstein* (Jürgens, 2019; Jürgens and Williamson, 2020), but also contemporary pop cultural characters, such as the Joker in comics and animated film (Jürgens et al., 2021a). Most of these scenarios revolved around violent body engineering using morbid, dark humor or slapstick. Slapstick—physical comedy emerging from foolish, often violent activities—is a common type of comic action in animated films (Islam et al., 2021). Like clownish behavior, which is expressed for example in wild pursuits and vigorous movement, it is mostly enjoyed by children and adolescents, and frequently employed in the audiovisual media aimed at these age groups, thus making their content more relatable to young audiences (Buijzen and Valkenburg, 2004). Traditionally (e.g., in circus contexts), the violence in slapstick is funny because it is presented in a comic frame that suggests that the performers themselves are not harmed, so the audience responds to the violent activities with laughter rather than concern or care for the performer (Peacock, 2014, 2020). It is therefore not surprising that slapstick plays an essential role in our animated series, a medium that serves as a comic frame with its anthropomorphism, but the way it shapes the image of science is remarkable and deserves more attention.

Uncannily reminiscent of the famous 1924 Seastrom film mentioned above, in SB, for example, Spongebob's lies lead to the Scientific Committee revoking the scientist's (Sandy) awards on the grounds that she is not clever enough, whereupon she protests in a slapstick rage to which the committee members comment: "it is always the dumb ones who are most violent" (SB-S6E9b). Science here, like in *He Who Gets Slapped* (Seastrom, 1924), becomes an enabler of comic violence, leading to the disintegration of Sandy's identity as a scientist and to her distancing from the scientific community. But overall, a carefree relationship with violence in the form of comic expressions of aggression, fighting and punching regularly accompanies the female scientists' lab work (SB-S1E8a, SB-S4E15a, SB-S6E9b, SB-S6E19b, SB-S7E12b). For example, in order to anesthetize a friend in her lab for a science experiment, Sandy karate chops his head (SB-S4E55a). In another instance, Sandy uses violence to punch, kick and karate chop to save her friends from comically anthropomorphized "germs" in a laboratory machine (SB-S5E12). Showing maliciousness and aggression, Sandy gets so angry with Spongebob and Patrick for destroying her lab that they run away in fear (SB-S8E13). Slapstick, anthropomorphism and malicious pleasure (Buijzen and Valkenburg, 2004) work in tandem to produce humor in these scenes. But labs themselves also produce the material for violent comic effects, for example, in an episode of AT the antagonist, Lemongrab, is administered chemicals (a hot chili "serum" prepared by PB) after extensive beatings and punching (AT-S3E5). PB, like Sandy, also shows aggression: in a fit of rage, PB destroys items on her desk in her laboratory after her assistant/butler suggests she pause her scientific work to give a suitor a chance at romance (AT-S5E21), while in a different episode (AT-S1E24) she breaks a table in rage at being taken away from her scientific tasks.

Repeatedly, the comic Frankensteinian results, or rather, "products" of scientific endeavor themselves tend to, or want to, perform violent acts for comic effect [if not built for pure pleasure, such as a tea robot (AT-S3 E13) or dancing robot (SB-S5E18)]. For example, an "elite" bubblegum machine robot police force is created by the female scientist, programmed for violence (AT-S5E46); another robot army is used to break every world record of "The Guinness O'Ripley Enormous Book of Curiosities, Oddities, and World Records"—with the help of science (SB-S9E1). Science in SB and AT thus enables comic violence, and comic violence appears in the series' science contexts as joyful transgression. Through the comic, violent science becomes a highly dramatic agent, while the humor also highlights the impossibility of developing and establishing order in a meaningful manner from scientific processes. Slapstick in the series is a vehicle for witty cultural references, targeting young audiences through clownish humor and violent delights (Buijzen and Valkenburg, 2004), but also their parents, who through this entertaining experience are gifted the vicarious pleasure of witnessing laboratory procedures and scenes they would probably not recreate (Peacock, 2020) but that can still deepen their encounters with the science theme (Burns et al., 2003).

4.1.2. Science and funny contrasts

Much of the science-related humor in our study examples emerged from the contrast between concepts and objects of different size—also referred to as the "incongruities of size" in humor research (Price, 2013, p. 42)—provoking humorous effects especially in conjunction with a reversal of power

relations and improbable, absurd, and non-sensical science procedures. The scientist in AT, for example, is shown in her lab diligently making a sandwich "scientifically" in a process worthy of the Ig Nobel Prize: she spins a cow in a centrifuge to make cheese (AT-S4E02). The scene is a superlative visual lab experience—and a task that requires no science at all. "Incongruity of size" is also embodied in PB's pet lab rat, whose name is Science. In one episode (AT-S3E13), PB, playing off verbal humor, urges her friends to leave the conduct of an experiment to Science (because the rat had observed her doing science earlier). Although these examples present historically undocumented and rather wondrous—suprising—facets of science in a humorous way, the activities of the protagonists are based on the same principles and structures as "traditional" non-fictional science practice (we recognize the science lab and scientific endeavor). The humor in these scenes echoes what has been highlighted in the research: conceptual incongruity, for example in the form of exaggeration, surprise or distortion of familiar concepts and situations, or scale in general, are prominent humor techniques in media aimed at young audiences (Buijzen and Valkenburg, 2004). Although several humor techniques outlined in Buijzen and Valkenburg's typology are built on oppositeness, such funny contrasts were not listed as independent elements.

A particularly remarkable set of funny contrasts results from the combination of science and the supernatural in our sample. The science lab acts as a trapdoor toward the unlikely, when comic "magic" appears under the guise of scientific experimentation and is juxtaposed with established understandings of science. In SB, Sandy finds traces of the non-sensical chemical element "jerktonium" using her "Christmas magic analyzer" invention in her home laboratory (SB-S8E13; the use of magic equating science is reflected explicitly in the series, see SB-S6E8b). In AT, PB's science brings people back to life (e.g., AT-S1E1) or turns them into zombies (AT-S3E13), and many of her experiments and comic "inventions"—while scientifically framed (e.g., through lab equipment and laboratory setting) – have more to do with the supernatural than science (see e.g., AT-S4E10, AT-S1E1, and AT-S7E11). This is especially true of science experiments gone wrong [e.g., when science, instead of helping to revive a character, causes pus to gush out of all orifices like a geyser, and turns the patient into a zombie (AT-S1E1 and AT-S3E13)]. Promoting and providing a more amplified vision of what science can do, the unexpected supernatural—which in fiction is traditionally not governed by any pressure of legitimization (Lachmann, 2002)—serves the reinterpretation (or recasting) of science. The supernatural also adds a humorous contraposition to the scientist's appearance (when wearing a labcoat with a witch hat, AT-S4E2) but also enhances the scientist's social status and relative power, for example when PB uses chemistry to create an heir to the throne in a comic Frankenstein act (AT-S4E10).

4.1.3. Science is mannerist chemistry and visual exaggeration

In both series studied, science-related humor generally arose from visual exaggeration of the scientific environment (laboratory) rather than verbal puns, irony or bombast (Buijzen and Valkenburg, 2004). In both shows the characters' designated science spaces were impossibly large chemistry laboratories with excessive amounts of equipment and resources (including X-ray machines and shrink rays) and larger-than-life computers (see above for humor and scale). These sensational laboratories offered unlimited access to medical, chemical, genetic coding and geophysical resources, and continuous streams of data (e.g., SB-S4E15a; AT-S2E09). As a result, the laboratories produce an array of fantastical products [including a "growth serum" for plants (SB-S8E15a) and an "instant bath serum" which makes one sweat cleaning agents (AT-S3E5)] by means of impossibly colored chemicals, idiosyncratic equipment, and extravagant or supernatural experiments that cannot be reproduced, turning the science lab into a space of joyful anarchy. Much of science defied logic and common sense and was highly stylized: ostentatiously presented and staged, with all sorts of colorful props. It strived for effect (by being shown to others and aiming to change others) and looked overwhelming. This is why—to use a term from art history that sums up these qualities—it can be called "mannerist," which in other contexts has been discussed as a feature of science in animated film (Jürgens, 2020). The humorous image of these mannerist science spaces and visual extravaganzas are based on the technique of visual exaggeration and eccentricity (Buijzen and Valkenburg, 2004). The mannerist laboratories of the TV shows also embody transformation, a form of humor that allows for surprising metamorphoses (Buijzen and Valkenburg, 2004).

4.2. Interim conclusion 1: Humorously framed science is non-science

Our study examples offered a multitude of references to non-fictional science practice, provided science and visual lab vocabulary, and depicted daily tasks that are known from real world scientific research. In doing so they affirmed established notions of scientific research and the cultural image, or imaginary, of "traditional" lab work. At the same time, they play with these notions and "rewrite" traditional science conventions and appearances by presenting unconventional and impossible experiments by means of different humor techniques. These include comic violence, funny contrasts and mannerist exaggeration (Figure 1). Many of the humor techniques in our animated TV episodes were among the techniques described in Buijzen and Valkenburg's (2004) typology, with the ones that they attributed to the media aimed at the younger audiences (slapstick, clownish behavior, anthropomorphism) being indeed

among the most prominent ways to create humor. However, we found that slapstick, funny contrasts or visual mannerism were not only action-inducing phenomena that tap into the improbability and the unexpectedness and of the scientific experiment, but also revolve around the power over bodies, and can be read as a commentary on the agency of scientist characters and on exerting agency on others by means of science [e.g., by transforming or (re)creating others comically through science]. A closer look at the science-related humor of the animated series revealed that it is often achieved by the combination of different techniques, as each individual technique does not always generate humor by itself (Buijzen and Valkenburg, 2004). However, our humor analysis also uncovered that the science in our TV shows is not actually science.

As we have seen in the examples, the scientists in our sample material do not strive for knowledge *per se* in order to unlock the secrets of the universe. They do not explore scientific methods to understand nature, make no risky predictions to follow scientific goals, do not employ strict scientific methods or accumulate scientific "data." They do not have hypotheses or verify anything. They sometimes approach nature with a "scientific" mind-set and methods reminiscent of those used in science (see above) only to discover something else (for example, themselves). The scientists fail to produce or present results or scholarly output that would enable them to describe a reality in space and time which is independent of themselves (Holton, 1978), which could be defined as a goal in science. Instead, the science conducted by our science protagonists leads primarily to nothing or to comic effects and creatures. Although they pursue quasi-magical activities, they cannot be considered revenants or distant relatives or even parodies of the mad scientist (see Haynes, 2017), as they do not follow arcane intellectual goals and sinister, ideologically evil, unlawful projects. Our examples seem to ridicule the idea that scientists are privileged "to be at the summit of knowledge" (Atkins, 1995, p. 123; Buijzen and Valkenburg, 2004). In short, their science is a form of non-science (Jürgens, 2019). Our study series present the scientific endeavor as an act of comically framed creative invention—and intervention. For example, before Sandy can take off to a trip to the moon in her rocket ship to collect rock specimens to study in her lab (SB-S1E8), a humorous homage to Melies (1902) cardinal *Trip to the Moon* (one of the most iconic films of early cinema), Spongebob and Patrick intervene, steal her rocketship and moon rock collecting devices. PB is also seen hosting a science convention (AT-S2E15) but does not perform any scientific tasks or is incapacitated (AT-S3E13) and cannot create the cure for candy zombies leaving the task to fall to science-novices.

However, embedded in scientific settings and by means of experiments, our fictional scientists do explore new frontiers, rebel against the status quo, and overall have a knack for seeing things in a different light, which have been defined as essential characteristics of scientists (Oliver, 1991). Diversely,

FIGURE 1
Interrelated humor types identified that characterize science in the series studied.

the shapes of science in our examples are not certain—but easily invented. Exploring how science is performed as fiction, these series manifest different dimensions of how fictional narratives can raise, test, confirm, complicate and parody the processes of science, if not knowledge acquisition. The female scientist, which is explored in the following, thus appears as the nerve-center in a pulsating network of identifications and confrontations of contrasting notions of both humor and science.

4.3. Femininity and science stereotypes in *Adventure Time* and *Spongebob Squarepants*

Science is a human endeavor, and the cultural influences and biases that permeate society are reflected in the science environment as they are in science communication and science imaginaries (Medin, 2012; Medin and Bang, 2014; Longnecker, 2016; Polk and Diver, 2020). As seen above, science in our study samples is framed in humorous ways as non-science; as a space of and for exaggeration, violent surprises and conceptual incongruity, which is both expected to be humorous for the age group of the television programs and surprisingly diverse [the funny contrasts and mannerist dimensions we discovered are not mentioned by Buijzen and Valkenburg (2004)]. How can the female scientist be comprehended and defined within this context? To what extent do non-science humor and the femininity of the characters play into the characterization of the protagonists as female scientists? What can we learn about female scientists from this portrayal? To better understand these phenomena in our study samples, the spectrum of stereotypical female scientist traits explored in both Flicker's (2003) discussion of fictional scientist stereotypes and O'Connor et al.'s (2018) analysis of feminine stereotypes in the STEM career field

TABLE 2 Feminine traits found in episodes of both shows during analysis.

Feminine trait	Trait identified by (references)	Princess Bubblegum in *Adventure Time*	Sandy in *Spongebob Squarepants*
Believes in goodness	Flicker (2003)	S1E1, S1E7, S3E5, S4E10, S4E26	S5E15b, S5E18, S6E19b, S8E15a
Deference to male authority	O'Connor et al. (2018)	S3E5, S5E21	S4E10b, S5E12, S6E9b
Delicate	O'Connor et al. (2018)	S1E1, S1E7, S1E24, S2E26, S3E5, S4E19, S4E20	S5E10a, S8E13a
Domestic/shown in the home	O'Connor et al. (2018)	S1E1, S1E7, S1E24, S2E9, S2E26, S3E5, S3E10, S3E13, S4E20, S4E26, S5E21	S4E15a, S5E10a, S5E18, S6E8a, S6E9b, S6E19b, S7E12b, S8E13, S8E15a
Emotional	O'Connor et al. (2018)	S1E1, S1E7, S1E24, S2E9, S2E15, S2E26, S3E5, S3E10, S4E16, S5E9, S5E21, S5E26	S4E15a, S5E4a, S6E8a, S6E9b, S6E19b, S7E12b, S8E13a
Femininity and success mutually exclusive	Flicker (2003)	S1E7, S5E21, S4E16, S5E21	S5E12
Heterosexual	O'Connor et al. (2018)	N/A - Not heterosexual	0 - No occurrences found
Intuitive/uses intuition	O'Connor et al. (2018)	S2E15, S4E10, S4E19, S4E20	S5E10a
Lacks professional recognition	Flicker (2003)	S3E5, S4E16, S5E26	S6E109b
Looks feminine	O'Connor et al. (2018)	All	S4E10b, S5E4a, S5E10a, S5E18, S6E9b, S6E19b, S6E8a, S6E9b, S8E13, S8E15a
Love interest	Flicker (2003)	S1E7, S1E24, S2E9, S2E15, S2E26, S3E5 S3E10, S4E16, S4E19, S5E21	0 - No instances found
Married to her work	Flicker (2003)	S1E1, S1E24, S3E13, S4E10, S4E26, S5E21, S5E26	S1E8a, s4e10b, S5E4a, S6E9b, S6E11, S6E19b, S8E13
Morally impeccable	Flicker (2003)	S1E1, S4E10	0 - No instances found
Naïve	Flicker (2003)	S1E1, S1E7, S2E15, S3E5, S3E13, S4E10	0 - No instances found
Nurturing	O'Connor et al. (2018)	S1E1, S1E7, S1E24, S2E15, S4E10, S4E19, S4 E20, S5E9, S5E21, S5E26	s4e15a
Obedience	O'Connor et al. (2018)	S5E26	S8E15a
Passive	O'Connor et al. (2018)	S1E7, S2E15, S2E26, S3E10,	S4E10b,
Sexual	Flicker (2003)	0 - No instances found	0 - No instances found
Socially competent	Flicker (2003)	S1E1, S1E7, S2E15, S4E20	S6 E19b
Subjective	O'Connor et al. (2018)	0 - No instances found	0 - No instances found
Submissive	O'Connor et al. (2018)	S3E5	S6E9b
Youthful	Flicker (2003)	All	All

proved useful. Table 2 and Figure 2 explore these actualized and fictional stereotypical feminine traits in relation to our study subjects.

4.3.1. Science and the fictional female scientist stereotypes

Our results showed that fictional science characters in our selection of animated television for adolescents were similar to that of both Flicker (2003) and O'Connor et al. (2018) such as the use of female intuition (SB-S5E10a), domesticity (SB-S4E10b), and nurturance (AT-S4E20) with both characters being extremely young, especially for their scientific competence. PB is also the main love interest for both female and male suitors (e.g. AT-S1E7; AT-S2E15; AT-S3E10). Sandy loses professional competence when her trophies are taken away by the Science Committee (SB-S6E9b), and scarpers before her bosses can see that she has yet to come up with a fruitful invention (SB-S4E10b). Both characters have varying degrees of traditional femininity, such as strong emotional reactions (SB-S1E8a; SB-S5E18b; SB-S6E9b; SB-S7E12b; AT-S2E15; AT-S3E10; AT-S5E26), predominantly pictured in the home (SB-S1E8a; SB S5E10a; SB S6E9b; AT-S4E2; AT-S5E9; AT-S5E21), and continuously in need of saving by less intelligent, brute male characters (SB-S1E8a; AT-S1E01; AT-S1E7; AT-S3E13; AT-S2E26). PB participates in both "girl

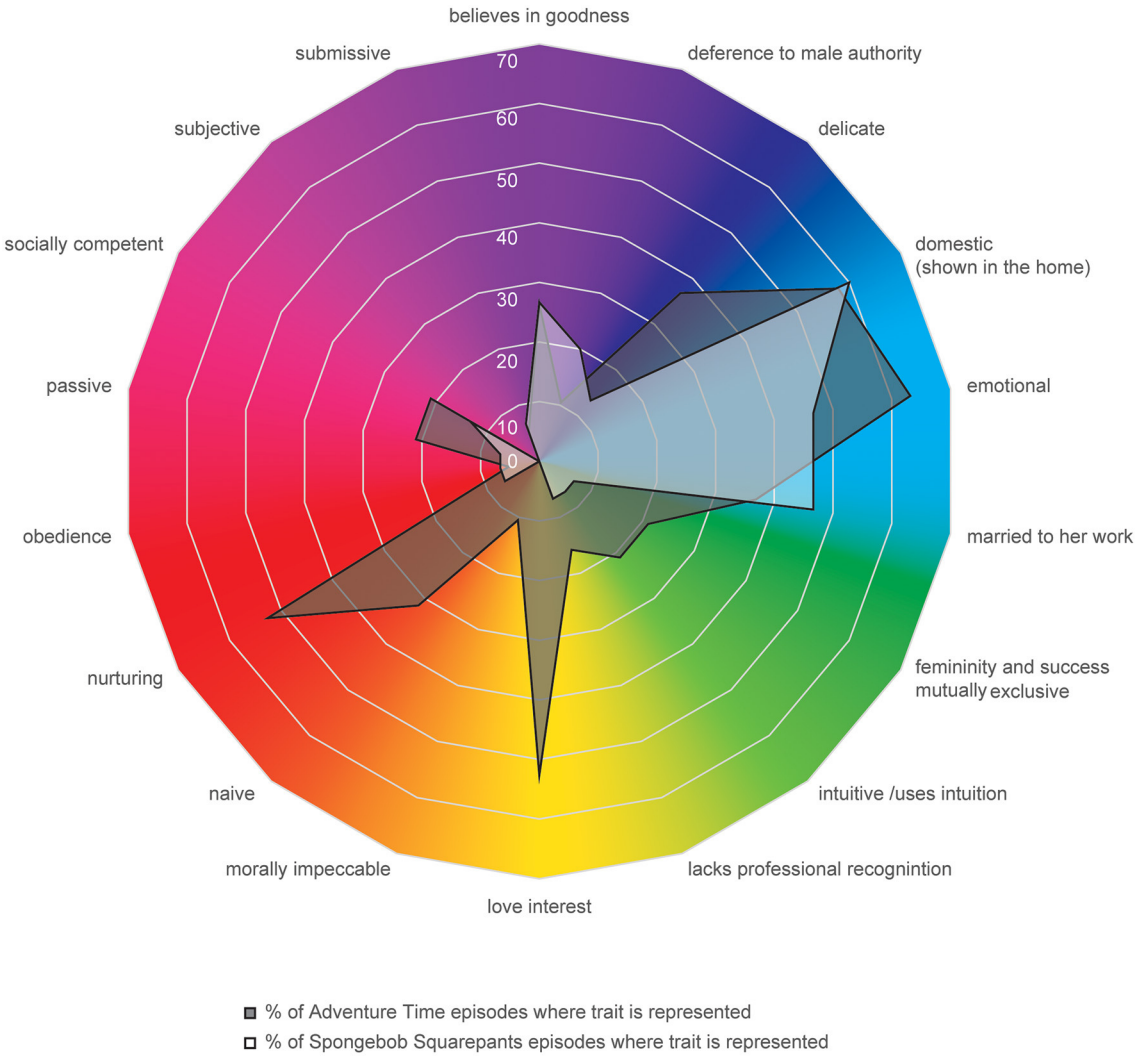

FIGURE 2
Radar plot depicting the percentage of episodes where feminine traits as outlined by Flicker (2003) and O'Connor et al. (2018) were found in each study subject (with Princess Bubblegum represented in black and Sandy represented in white). The gradient of color in the background represents the spectrum of femininity and the melding of traits to create a concentrated whole; and that femininity exists on a gradient/spectrum with an infinite number (color) of possibilities of expression.

culture" (AT-S4E2) and gossip (AT-S4E10; AT-S5E29) and is the matriarch of her show; although she does not bear children she often "creates" other candy people (AT-S3E5; AT-S4E10) and is almost always portrayed in a caretaking position (AT-S4E20). These characters are seen in varying contrasts of femininity and the female scientist stereotype, thus fitting these children's media characters into similar stereotypes as their adult counterparts in adult media. However, we also note that the ideas of femininity and science, historically incompatible, are challenged by the feminization of what scientists can look like, how they can act and present. In addition to the aforementioned feminine traits, we also found occurrences concurring with Flicker's (2003) observations that in fiction, female characters are habitually depicted in relation to male characters, either as a love interest or scientific mentor and thus do not exist in a world without male superiority, similar to "real life" science workplaces found in O'Connor et al. (2018). Flicker (2003) proposed that fictional female scientists in entertainment media exist within the bounds of six stereotypes—all of which have elements of femininity that lead to her downfall as a competent scientist. In the following sections we outline the theories presented by Flicker (2003) and O'Connor et al. (2018) and give examples from our study sample.

4.3.2. Relation to men

Flicker (2003) and O'Connor et al.'s (2018) stereotypes highlight that in relation to men, the female science character is subordinate. We found in our study, the female science character is the sole traveler on the scientific road and has no male mentor, however, she is still tied in some relation to a male character whether professionally or personally. In SB (SB-S4E10b) Sandy is at the whims of her older, male, academic bosses (portrayed through exaggerated dress, bombast language and pompous attitudes) who control her funding; a satire on the academic trope (Buijzen and Valkenburg, 2004). However, she is asexual and a platonic friend for the main character Spongebob, contrasting Flicker's (2003) findings.

PB's relationship to male characters is contrasting; she is not owned nor governed by male superiors, however she does have complicated and difficult relationships with male characters as the main love interest. These romantic relationships sometimes come between PB and science; or try to. In AT-S5E21, PB must choose between a suitor and science, giving the illusion of the fictional female scientist having autonomy over her choices rather than the reality of only being able to pursue a singular life endeavor (romance or a career). Her growth as a character is solely romantic and does not extend to that of her scientific knowledge, qualifications or personal growth as an individual. In addition, we found that the female scientist character's relation to men—for example, the pursuit of PB by a myriad of waggish characters—was such a recurring theme throughout the series that can be defined as humorous repetition (Buijzen and Valkenburg, 2004).

4.3.3. Female intuition and emotion

Another characteristic of the female scientist stereotypes is the use of feminine intuition (O'Connor et al., 2018) and "feminine emotions" (Flicker, 2003, p. 312) instead of rational decision-making, which has historically been reserved for male scientists—real and fictional—rendering the female scientist's scientific work less logical and more instinctual. These attributes are both reinforced and challenged by the series studied.

AT (AT-S3E10) challenges these stereotypes when PB tries to use logic and rationality to open a magical door and fails (AT-S4E19) and also uses rationality even in terms of romantic relationships. She explains love in scientific metaphors (AT-S4E16): "love is like levels of sedimentary rock," alluding that even her approach to emotion is calculated and rational. Similar phenomena appear in SB (see e.g., SB-S5E10a, SB-S4E75a, and SB-S1E8a). By showing female scientists using rational thought instead of solely intuition, the above stereotypes are challenged and thus lead to a diversification of what a female scientist is capable of, engendering diversified and coalescing imagery of the profession. This is amplified by the undercurrent of humor that accompanies these characters: their rationality leads to situations in which they make a fool of themselves, verbally or non-verbally (Buijzen and Valkenburg, 2004), such as when PB denounces magic for the sake of science but ends up landing her whole posse in wizard jail. However, both characters are seen as emotional (SB-S6E9b; SB-S6E19b; AT-S3E5, AT-S3E10, and AT-S4E16), which reinforces the stereotypes. Their emotions sometimes become larger than life, changing their physical attributes [in what Buijzen and Valkenburg (2004) would classify as clownish behavior] with these emotions often getting them into trouble, either scientifically or personally which occasionally leads to their scientific demise.

4.3.4. The look of a scientist

The look of a female scientist in our analysis was varied, but still traditionally feminine—and heavily scrutinized (as in e.g., AT-S2E26 when the Ice King insists that doctors cure PB from her sickly condition so his "future wife was not physically unattractive"). The look of science is often heavily scrutinized by the public (Banchefsky et al., 2016) and studies have shown that even from a young age children cognize what scientists are "supposed" to look like (Steinke et al., 2007; Banchefsky et al., 2016) with many interpreting science as a male profession. Cultural perceptions of what a scientist looks like, including appearance specifically, has been shown to be a barrier to attracting and retaining women in science (e.g., Chimba and Kitzinger, 2010; Cheryan et al., 2013a; O'Connell and McKinnon, 2021).

Sandy, while performing non-science acts (such as doing strange experiments and creating inventions) is often shown in her gray, gender-enigmatic space suit; other times she is seen in a purple bikini (a parody of the ubiquitous lab coat? Who does science in a bikini?); and in one episode (SB-S6E19b) she is even putting the finishing touches on her invention (a cloning machine) in a formal evening gown; her look as a scientist offers visual surprises (see Buijzen and Valkenburg, 2004, p. 161). The audience is made aware of Sandy's femininity because even her utilitarian space suit is accompanied by a feminizing pink flower. Alternatively, while she is wearing her bikini, her breasts are large and dominate her anthropomorphized (Buijzen and Valkenburg, 2004) and petite frame. However, her femininity rarely stops her from doing her job (SB-S4E10b; SB-S8E13a). The fact that she is female has nothing to do with the fact that she is a scientist and is often presented as "one of the boys." Patrick even exclaimed aloud "Sandy's a girl?" after she rips her space suit off, revealing her bikini (SB-S2E32a). We can see the rejection of traditional femininity and therefore more credence within her profession in Sandy's character, which subsequently coincides with Flicker's (2003) Male Woman stereotype. However, her femininity as a character can be complicated. Sandy's femininity may be seen as a barrier for girls lionizing her as a female scientist, as she perpetually denounces traditional femininity. Her outcry at finding the lost city of Atlantis and her disbelief

in a place where intelligence is valued over beauty (SB-S5E92) rejects traditional gender roles (enjoying looking and feeling beautiful) to capitalize on and conform to more traditional male qualities (flaunting intelligence). Because of the shedding of her traditional feminine qualities it is more believable that Sandy is a scientist (Banchefsky et al., 2016). So although she has feminine looks in terms of dress, Sandy's denouncement of traditional feminine qualities unidimensionalizes the idea of the female scientist and what interests (that are traditionally "girly") outside of science she is "allowed" to participate in. While rejecting aspects of femininity to fit the look of a scientist, she also perpetuates the degradation of feminine looking science and scientists which reinforces the genderedness of science (Charles and Bradley, 2009; Charles, 2011; Archer et al., 2012a; Betz and Sekaquaptewa, 2012; Banchefsky et al., 2016). More masculine than feminine qualities could erroneously cause children to think that scientists cannot look or present as feminine.

Princess Bubblegum also has a feminine physical appearance with large eyes and hair (as with everything else in her life) in her signature shade of pink. She sometimes wears a lab coat over her elegant, pink princess gown to perform non-science (AT-S4E10; AT-S5E9; AT-S5E21). Her visual appearance as a scientist is thus surprising (Buijzen and Valkenburg, 2004). Oftentimes when she is "doing" science, and especially in later episodes of the series, she trades her dress for (pink) pants (AT-S5E29), somewhat a rejection of stereotypically feminine presentation (Ellemers, 2018). Her Western, idealized beauty is made known to both the audience and other characters with bodily features such as long hair, petite facial features, and thinness. In this sense, she reinforces Flicker (2003) and O'Connor et al.'s (2018) stereotypes of the female scientist being extremely young and beautiful, while still holding scientific competence. Her girliness, however, challenges traditional science character coding by giving her qualities that are traditionally not compatible with science characters. Although she still sits within the confines of some of the above stereotypes, PB's rebellious glorification of all things pink and girly, while still holding professional competence as a scientist, challenges these stereotypes of what a scientist can look like.

4.3.5. The feminization of the science theme

The stereotypes found in Flicker (2003) reveal a narrow scope for who a female scientist *is* in popular media. She is young, married to her work, has a relationship with a man (either as a love interest or scientific mentor), is professionally competent but loses an element of her femininity at the hands of her professional life or vice versa, believes in goodness, and is morally impeccable. These traits seem varied and multidimensional with room for character growth and complexity, however they are all tied to the sex-role theory of feminine subordination to men. Concurrently, we found both female science characters in our study possessed an overabundance of exaggerated scientific knowledge—far more experience than their age would suggest, with performance of many different types of science including, but not limited to, chemistry, engineering, rocket science, and medicine. Humorously framed science, or rather non-science (see above), although conducted almost solely by the female scientist, was often the catalyst for comic catastrophe, or saw their experiments "go wrong" (e.g., SB-S8E13b; AT-S3E5) giving the overall impression that female scientists are somehow scientifically incompetent. It was also of note that both female scientific characters were presented as altruistic regardless of the outcome, even if catastrophic.

As with other media studied, our characters' careers were paramount to their identities (Kosut, 2012) but both their behaviors and appearance "mimic[ed] stereotypical gender roles" (Kosut, 2012, p. 130). On the surface these characters were strong, competent and intellectually superior to their male counterparts (AT-S2E9). They were not weak and could hold their argument with male characters (SB-S4E15a), in this way they appear to be intelligent, strong and emancipated. However, the "feminization" of science portrayed in these two children's series is a double edged sword. It is beneficial to show realistic representations of who is allowed to be a scientist and what scientists are allowed to look like, but it also makes it more difficult for those scientists to maneuver within their scientific realms. Children are influenced by and influence society, thus what they see in entertainment, media, education, and even toys (Lee-Cultura et al., 2018) forms part of their understanding of the "way the world works." We come back to Archer et al. (2012a) and note the balancing act that girls—and the women they grow up to be—must perform in order to fit the mold of science.

While our female scientist characters were complex, ultimately we were able to align them with O'Connor et al.'s (2018) observed traits and Flicker's (2003) archetypes. Although she has characteristics of (almost) all of Flicker's female scientist stereotypes, Sandy's personality aligns most closely with that of the Male Woman. She is practical and assertive within a male environment, and similar to the stereotype of the male scientist (Flicker, 2003). Most notably Sandy's "existence as a woman does not play a role in terms of femininity" (Flicker, 2003, p. 311) and is "inferior to her male colleagues"' (p. 311). PB, on the other hand, is a "modern, emancipated woman" (Flicker, 2003, p. 315) and naturally moves within traditionally male-dominated environments and positions of power, especially as monarch of the Candy Kingdom. Although queer characters were not identified or extrapolated in Flicker's (2003) work, it is worth noting that PB is openly bisexual. However, within the canon of the show this is normalized and unmentioned by her or other characters. Although she is a queer character she is female coded and is still a love interest of both male and female suitors. PB falls somewhere between the Naive Expert and the Lonely Heroine stereotypes (Flicker, 2003). Additionally

she is incredibly competent, even more so than her male co-stars, and is a strong character, nevertheless it is ultimately her relationships with men that define her role.

These characters, then, both reinforce and challenge the stereotypes presented in Flicker (2003) and O'Connor et al. (2018). While certain parts of both fictional characters' attributes adhere to stereotypical traits defined by both authors in the framework, we found some diversity and more modern performances of femininity in science in our sample. Both characters are expansions on Flicker's (2003) stereotypes and the myriad of the character's experiences show complex women in scientific roles/professions and challenge science's "gender order" (O'Connor et al., 2018, p. 313).

4.4. Interim conclusion 2: Humor and the stereotype of the female scientist

While the female scientists in our study examples certainly had humorous characteristics, our analysis shows that it is the science that is humorous, not the female scientists *per se*. Harmonious with developmental theories of humor appreciation (Buijzen and Valkenburg, 2004), the humor associated with our female scientists oscillated between clownish and illogical behavior, eccentricity, comic violence, and visual extravaganzas and surprises, but it unfolded mainly in the context of non-science work or parody-science in the laboratory. The insignia of the exaggerated and mannerist form the substrate of their non-science in our examples, where the affinity between science and humor is based on the comic hyperbolic, in which the transgression of truth and the overstretching of the probable (and proportionality) are inherent, and which expresses itself in creative, comic laboratory virtuosity that re-negotiates elementary questions of individual self-understanding as well as biological and cultural origins. The science lab of our female scientists appears as a place of tricky (illusory) productions providing an expanded vision of what science can do, where tradition does not mean stagnation, and where humor can influence the causality of fictional science. The humorously framed laboratory presents science as an artificial creation. Here, the body often represents the material for the creative act that reveals itself in science performances. In our study sample, humor-infused science served to create individual, cultural and historical meaning: it offered a territory for the confrontation and identification of different cultural references, for the contrasting of ideas of the completely extraordinary and prosaic, as well as of authenticity, originality and supernatural.

5. Conclusion

Our study explored the use of humor to communicate and counter social conventions about science and gender. In this study we analyzed the connection of "what is shown and what can be perceived as real" in the science environments in selected episodes of animated TV series for young audiences—as sites of cultural circulation—where diverse discourses, aesthetic practices and imagined worlds interact (Flicker, 2008, p. 243). We analyzed 15 of 248 episodes of the TV series *Spongebob Squarepants* and 19 of 283 episodes of *Adventure Time* to better understand how their female scientist protagonists were portrayed through humor, and how their portrayal reinforced or challenged gender conventions in these fictional representations of the scientific profession aimed at young audiences.

We interpreted our study episodes in light of Buijzen and Valkenburg (2004) humor typology and Flicker's (2003) and O'Connor et al.'s (2018) discussions of female scientist stereotypes and femininity. We discovered that it was not the female scientists themselves, but science—its visual representation and processes—that was associated with humor in the form of exaggeration and funny contrasts. These strategies and comic violence in the lab turned science into humorous non-science that explored fantastic possibilities or extended versions of what science could be—or, in other words, the potential of science (Davies et al., 2019). We know that humor can be advantageous to science (Chateau-Smith, 2016) as a pedagogical tool as it has the ability to foster positive social perceptions of and accessibility to (unreachable) topics and boost attention to communication and recollection of its contents (Riesch, 2015; see Section 1). The forms of humor used in the portrayal of science in our study examples were techniques aimed at evoking mirth and enjoyment (Meyer, 2000; Buijzen and Valkenburg, 2004)—and enjoyment is "a highly desirable component of all science communication" (Burns et al., 2003, p. 197). Enjoyment "may evoke positive feelings and attitudes that may lead to subsequent, deeper encounters with science" and thus contribute to "healthy scientific culture within society" (Burns et al., 2003, p. 197).

The types of humor that we detected in our study examples largely correspond to children's and adolescents' preferences for humor (Buijzen and Valkenburg, 2004), but we also discovered techniques, such as funny contrasts and mannerist exaggeration, that were not listed as independent elements in their typology. The less visible place of humor based on contrasts in Buijzen and Valkenburg (2004) study may derive from the fact that the media they analyzed was commercials and not animated films. But what is it that generates science humor in our TV series? The humorousness of the more innocuous humor (clownish behavior, exaggeration, and surprise) can be explained with the incongruity theory, while the slapstick can be grasped with the relief theory (Buijzen and Valkenburg, 2004, p. 162–163; see above). While the depiction of science in our TV shows is certainly not a veiled criticism of questionable or trivial research, we could not ignore a certain parodistic underbelly. Parody is a relatively complicated and abstract form of humor that requires more developed cognitive skills, which is a humor type

aimed at adolescents, and thus the older children in the age group of our TV series. Further research can investigate this phenomenon in more detail and in other fictional examples, and how the specific humor strategies that we discovered (funny contrasts, mannerist exaggeration, etc.) can address the issue of underrepresentation and marginalization of women in science as manifestations of larger social and cultural ideologies. Within these contexts, a better understanding of how humorous science content influences attitude formation and our behavioral intentions of young audiences could also help communicators make informed strategic decisions regarding the use of humor in practice.

Fiction, the medium of our animated series, itself can have powerful effects on young audiences. Creating an immersive "melding of attention, imagery and feelings" (Davies et al., 2019, p. 8), narrative and visual fiction in general, and our study examples in particular, can influence audiences' perceptions of their own worlds (Stroud, 2008; Mathies, 2020).

> *"Fiction may help general as well as scientist readers to find new ways of engaging with 'science and society' in both directions: in relation to the role and relevance of science in various forms of social settings, and also in relation to the role of social, individual, and cultural factors built into the practice of science for whose critical analysis and discussion scientific discourses themselves provide little space. The construction of complex scientist characters as problematic individuals appears as the privileged device for realizing this potential."* (Kirchhofer and Roxburgh, 2016, p. 167).

Our female protagonists certainly are complex characters, as our analysis uncovered. Our examples echo and reflect gendered experiences of and in the scientific profession—in relation to men, female emotion and appearance—but they also serve as a platform to challenge and subvert traditional stereotypes and ridicule patriarchal power structures; power structures that "should be neutral and ungendered, particularly because scientists generally stress the need for objectivity in research" (Hall, 2010, p. 17). However, the female scientist protagonists in *Spongebob Squarepants* and *Adventure Time*, this study showed, challenge the stereotype that women in science are unidimensional—rather they are colorful and lead interesting, unique and diverse lives with multiple interests (not just science) and not just love. However, our findings also confirmed Flicker's argument that fictional female scientists can appear powerful and practice presence in the science field but still remain dependent on male characters (e.g., when they are "saved" or rescued), even if this is embedded in a representation of science that is only an approximation of social reality (and more non-science than science). Femininity and science are not mutually exclusive; the augmentation of science and cultural artifacts by feminine input could be quite advantageous to the rigor of laboratories and the like. Normalizing humor, femininity and science may help form a broader understanding of who is allowed to be a scientist.

As we have discussed, although the characters have heterogeneous personality traits and personal interests, many of their core attributes fall within Flicker's stereotypical female scientist stereotypes, reinforcing the very barriers feminism seeks to deconstruct. Perpetuating such stereotypes can be detrimental to young audiences, particularly young girls aged 10–14 (Archer et al., 2012b), as they may internalize such stereotypes and develop negative attitudes toward science, and science careers (Steinke, 2017; Mitchell and McKinnon, 2019). Conversely however, young girl's interest in scientific topics after that age can be bolstered by positive female scientist role models, real and fictional (Bemrose, 2020). Thus, decoding the nuances of female science characters in children's TV may assist in further exploration into young audiences' perceptions of scientific themes, gender norms, and young girls' place in the scientific field.

Finally, we, the authors, are aware that not only are we all female, but we also bring our own biases in favor of women in science to this research and align ourselves with a belief system aimed at inspiring and engaging young women in science. We are also aware that the relatively small selection of study episodes may raise the question of how generalizable the results of our analysis are to other TV series for young audiences. Indeed, qualitative research with smaller sample sizes or "data" collections are often criticized for not being transferrable to other settings (Quieros et al., 2017; Rahman, 2017). However, the goal of qualitative, interpretive research is to obtain a rich understanding of the data which may be unique and context-dependent (Gheondea-Eladi, 2014; Leung, 2015), which is the core of our study. Our paper adds new dimensions to Pansegrau's (2007, p. 257) statement that the media does not simply translate "scientific information but are participants as well as producers of a dialogue about knowledge and have an important function within the public discourse." Similarly, this study supports the idea that humor and entertainment are forming part of and legitimizing a particular set of cultural discourses with regard to identities and types of social relations (Jontes and Trdina, 2018). However, more work needs to be done to better understand the cultural construction of science through media as related to gender and the lack of gender representation and participation. In these contexts, it might be also useful to further extend this to a discussion of how ideas that associate masculinity with science actually developed, thus excluding and marginalizing women in science.

Is the message of our fictional TV examples thus "that a society produces the scientists it deserves" (Haynes, 2017, p. 312)? It seems that there is still a long way to go for diversified and unique female science characters that move beyond stereotypes. It may be that practicing fluid femininity—and masculinity—in all its glory is, by its

very nature, rebellious against traditional sex and gender and social norms, thus paving the way for future female scientists to flourish in all of their "girly" (Francis et al., 2017) and scientific endeavors with little credence to the status quo.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

JS-H had the idea for this manuscript, which materialized out of a report she prepared for a course taught by A-SJ with the support of KJ. JS-H collected and analyzed the series episodes. KJ reviewed a selection of key episodes against the selection criteria. While all sections went through many iterations created and revised together over the many months that the authors worked on this manuscript, KJ acted as the expert on the women in STEM research context, A-SJ as the expert on the humor research and cultural dimensions of science communication contexts, and JS-H as the expert on the series content, their research context, film analysis and the young audience context. JS-H and KJ did the main work on the sections on female scientists and femininity, A-SJ worked on the sections on science and humor and the methods-but all sections went through multiple cooperative revisions. All authors enjoyed working on this manuscript and it was a very collaborative process. All authors contributed to the article and approved the submitted version.

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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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