YouTube Science Channel Video Presenters and Comments: Female Friendly or Vestiges of Sexism?[1]

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Abstract

Purpose: This paper analyses popular YouTube science video channels for evidence of attractiveness to a female audience.

Design/methodology/approach: The influence of presenter gender and commenter sentiment towards males and females is investigated for 50 YouTube science channels with a combined view-count approaching ten billion. This is cross-referenced with commenter gender as a proxy for audience gender.

Findings: The ratio of male to female commenters varies between 1 and 39 to 1, but the low proportions of females seem to be due to the topic or presentation style rather than the gender of the presenter or the attitudes of the commenters. Although male commenters were more hostile to other males than to females, a few posted inappropriate sexual references that may alienate females.

Research limitations: Comments reflect a tiny and biased sample of YouTube science channel viewers and so their analysis provides weak evidence.

Practical implications: Sexist behaviour in YouTube commenting needs to be combatted but the data suggests that gender balance in online science presenters should not be the primary concern of channel owners.

Originality/value: This is the largest scale analysis of gender in YouTube science communication.

1. Introduction

Women are underrepresented in science. In almost all countries in the world, there are more publishing male scientists, with proportions varying by field. This underrepresentation is continuing despite progress in recent years and its causes are unclear (Sugimoto, Larivière, Ni, Gingras, & Cronin, 2013). Contributory or associating factors include lower female respect for science, fewer female scientist role models, poor pedagogy in science classes, sexist course materials, cultural pressure (Blickenstaff, 2005) and gender stereotypes (Ceci, Williams, & Barnett, 2009; Miller, Eagly, & Linn, 2015; Smyth & Nosek, 2015). More generally, females are underrepresented in STEM (Science, Technology, Engineering and Maths) disciplines (Cesarsky & Walker, 2010; Ivie & Tesfaye, 2012; Kirkup, Zalevski, Maruyama, & Batool, 2010; National Science Foundation, 2017). In quantitative fields, continuing gender differences in the USA are not caused by biases against women within academia; instead the socially constrained choices made by women seem to explain differing career outcomes (Ceci & Williams, 2011). For example, young female biological scientists may be less focused on authoring publications, damaging their long term academic career prospects (Feldon, Peugh, Maher, Roksa, & Tofel-Grehl, 2017). It is therefore important to understand the social context in which women choose science-

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related careers and their decisions at the start of these careers. This may reveal some ways in which they are alienated from research.

The internet and YouTube are obvious choices for investigating gender issues in science education. YouTube contains many different types of science-related videos, including many that are documentary, recreational and educational (Erviti & Stengler, 2016; Muñoz Morcillo, Czurda, & Trotha, 2016). It is widely used in school classrooms and by university students to support learning (e.g., Barry, Marzouk, Chulak-Oglu, Bennett, Tierney, & O'Keeffe, 2016; Tan & Pearce, 2012) as well as for leisure-time explorations of science related content, such as by watching TED Talks videos (see below) or science-related music videos (Allgaier, 2013). It is also used as a research source (Kousha, Thelwall, & Abdoli, 2012).

Although the provision of free, high quality science content on the world's second most popular website YouTube (www.alexa.com/siteinfo/youtube.com on 9 June 2017) is a societal benefit, it is concerning from a women's empowerment perspective because YouTube is a male-dominated corner of the internet. It has been the site of misogynist abuse (Jane, 2014; Mourey, 2015; Wotanis & McMillan, 2014) and inappropriate personal comments (Molyneaux, O'Donnell, Gibson, & Singer, 2008), even though positivity is more common (Thelwall, Sud, & Vis, 2012). In male-dominated online spaces, gendered abuse and stereotyping can thrive and become normalised so that females must try to cope with it or combat it (Nardi, 2010). For example, a comparison of two high profile successful YouTube comedians found that the woman was more criticised and subjected to more personal comments (Wotanis & McMillan, 2014). Despite this, YouTube has seen the emergence of more gender-inclusive cultures (Morris & Anderson, 2015) and so it is not clear that science channels, if male dominated, would be unwelcoming for female viewers.

Gender is a factor in the popularity of YouTube science-related channels. Professionally produced YouTube science videos seem to be more popular if they have a male presenter, although the same is not true for amateur content and it is not known whether the popularity is due to an increased male or female audience (Welbourne & Grant, 2016). For TED Talks, male-presented videos are more popular (Sugimoto, Thelwall, Larivière, Tsou, Mongeon, & Macaluso, 2013) but female presenters are more likely to elicit positive or negative comments (Tsou, Thelwall, Mongeon, & Sugimoto, 2014). For the Khan Academy YouTube science channel, 80% of commenters are male (Saurabh & Sairam, 2013). Unless this is a special case or commenters are a highly gender-biased audience sample, it seems that the YouTube audience for science videos is primarily male. In other genres, such as TV, male presenters may also be more popular with female viewers (Sánchez Olmos & Hidalgo Marí, 2016).

The predominance of males in some areas of science and YouTube raises the possibility that hostile language (Alonzo & Aiken, 2004; Kayany, 1998; Lapidot-Lefler & Barak, 2012; Moor, Heuvelman, & Verleur, 2010) may alienate female science channel viewers. It tends to originate from males (Alonzo & Aiken, 2004) and is not necessarily related to the content of a video (Lange, 2007). Males on YouTube are more likely to comment on the attractiveness of vloggers (Molyneaux, O'Donnell, Gibson, & Singer, 2008), and prominent female YouTubers are routinely forced to deal with threatening sexist abuse (Mourey, 2015). Offline, male sexual humour is used to relieve anxieties about masculinity (O'Connor, Ford, & Banos, in press; Pascoe, 2013). In this context, commenters may perceive inappropriate sexual references as being humorous and inoffensive. This would be a mistake because, for example, the occasional "low level" sexist behaviour (or

microagression) that is a fact of life for some women in physics and astronomy has tangible impacts. These include the consequent social pressure on females to manage their appearance to be perceived as serious and intelligent by their colleagues (Barthelemy, McCormick, & Henderson, 2016).

From the above review, males are likely to dominate the presenters and viewers of YouTube science videos, potentially creating an unwelcome space for female viewers. Nonetheless, no previous study has sought evidence of the reasons for gender imbalances on YouTube science videos or attempted to provide recommendations for attracting a wider audience. The current paper addresses this gap by comparing the gender ratios of the audiences of a set of popular science channels (RQ1). It also seeks evidence of an alienating environment for women by male presenters or in the sentiments expressed towards females in the comments left underneath the videos (primarily RQ2b). This is driven by the following research questions.

- RQ1: Are females less likely to watch YouTube science channels that have male presenters?
- RQ2a (MF+<FF+): Are male science video commenters less positive than female science video commenters when discussing females?
- RQ2b (MF->FF-): Are male science video commenters more negative than female science video commenters when discussing females?
- RQ2c (MM+<FM+): Are male science video commenters less positive than female science video commenters when discussing males?
- RQ2d (MM->FM-): Are male science video commenters more negative than female science video commenters when discussing males?

2. Methods

The overall research design was to obtain a large sample of popular YouTube science channels to investigate the influence of presenter gender on the ratio of male to female commenters (RQ1) and to look for evidence of hostility towards women in their comments (RQ2). This is a novel approach that could be contrasted with more exploratory strategies for YouTube comment analysis (e.g., Thelwall, in press-a).

2.1 YouTube science channels

There are many different science channels on YouTube and so a method was needed to obtain a definitive list. A YouTube channel search for the keyword Science yielded 11,192,130 channels, including some, like *Holy Fucking Science*, that emphasise entertainment. Web searches were therefore used instead to identify recommended lists of varied but high quality science channels. The best list found was that of the GeekWrapped science gadget website https://www.geekwrapped.com/posts/youtube-science-rockstars-shows. Whilst this list is from a commercial site rather than a reputable source, all channels are popular and contain high quality science content. The use of a specific list is important for increased objectivity in comparison to a manually generated list. A manually-created list would be the result of subjective decisions made by the research team that might subconsciously be affected by the research goals. Such a list could also be accused of being selected to demonstrate the research goals. The first fifty channels from the pre-existing list were used as the raw data for this paper, except that two were lists rather than channels and were replaced by the 51st and 52nd channels.

2.2 Channel information, presenters, commenters and comments

The list of videos in each channel and the comments on these videos were downloaded using the YouTube API 5-8 June 2017 in the free software Mozdeh (http://mozdeh.wlv.ac.uk). For each channel, only one comment was allowed per user (the most recent one on the most recent video) to prevent individual prolific commenters from influencing the results. For videos with many comments, YouTube returns the most recent about 350.

The gender of each commenter was inferred from their username. When possible (either through spaces or camel case) usernames were split into multiple parts. If the first part matched a name that was used at least 90% by males or females in the US census (e.g., see: Sugimoto, Larivière, Ni, Gingras, & Cronin, 2013) then the commenter was assigned that gender. First parts of Mr, Mrs, Ms and Miss were also assigned to the appropriate gender. Most usernames did not match these rules and were left unassigned. For example, only 35% of Tyler DeWitt and 23% of Explorium commenters were assigned a gender. From manual checks of the results in the current and previous projects, this process seems to have an accuracy level of considerably above 90% in terms of the gender projected by the name, if not the (unknown) gender of the user. The only potentially incorrect classification found in the manual checks was Hui Yang (assigned as female). Whilst Hui is more common for females, at least in the U.S. 1990 census, it can also be used by males. The name-based gender identification procedure will generate some false matches and does not work for transgender individuals but can identify a predominantly male group and a predominantly female group. A US source was chosen for the name list because the USA is the largest user of YouTube, is a multi-cultural nation, and has an informal naming tradition that captures many shortened name forms (e.g., Lizzie). It is not possible to check whether the method has a greater success rate for one gender, biasing the results, because most of the unassigned usernames are gender neutral (e.g., names like Newb33, CouscousLover). Nevertheless, any bias seems likely to be constant between channels so the main fact that it may influence is the overall proportion of female commenters.

Commenting on a YouTube video is a way to interact with its creator or other users. Many comments are factual or short statements but some address other people by name or with a pronoun. Gendered pronouns were used as a universal method to identify that a comment was referring to a male or female. Comments matching the query *he his him man boy himself -she -her -woman -girl -herself* were assumed to be comments to or about a male and comments matching the query *she her woman girl herself -he -his -him -man -boy -himself* were assumed to be about a female. These are heuristics because people may be referred to by name (e.g., Mary, Nick) but the advantage of pronouns is that they suggest a deeper involvement in the person referred to by the fact that they do not need to be individually named, or are discussed multiple times so that they do not need to be named every time that they are referred to in a comment.

Commenter gender information was combined with pronoun queries to generate four separate sets of comments for each channel, each containing at most one comment from each user.

- MM: Male-authored comments containing exclusively male pronouns.
- MF: Male-authored comments containing exclusively female pronouns.
- FM: Female-authored comments containing exclusively male pronouns.
- FF: Female -authored comments containing exclusively female pronouns.

For some channels, there were few or no comments in the FF category and so the data set for the second research question was restricted to the 32 videos with the most comments. This gave a simple cut-off since the 33rd channel had no FF comments.

2.3 Sentiment towards presenters in comments

The strength of positive and negative sentiment in each comment in the MM, MF, FM, and FF groups was identified with the software SentiStrength (sentistrength.wlv.ac.uk) that exploits a lexicon of sentiment terms in addition to a set of linguistic rules (e.g., for negation, idioms and booster words) to estimate the strength of positivity and negativity in a text. It assigns a score of 1 (no positivity) to 5 (very strong positivity) and a second, independent score of 1 (no negativity) to 5 (very strong negativity) to each text. For example, the comment, "Great point about pi!" would score 4 for positivity because of the word *great*, which is in SentiStrength's lexicon with a default score of +3, and the exclamation mark, which boosts the strength of the positive sentiment by 1. It scores -1 for negativity, indicating no negative sentiment (zeros are not used). Lexical software that uses a pre-defined list of sentiment terms and additional linguistic rules (Taboada, Brooke, Tofiloski, Voll, & Stede, 2011) like SentiStrength is preferable to machine learning (Pang & Lee, 2008) for social science research purposes because the latter can detect controversial topics as proxies for sentiment (Thelwall, Buckley, & Paltoglou, 2012). SentiStrength was chosen for accuracy approaching human-level on YouTube comments (as found by comparisons between its results and three human coders for a random set of YouTube comments: Thelwall, Buckley, & Paltoglou, 2012) as well as for its dual system that allows negative sentiment to be analysed independently from positive sentiment, which is important for the research goals. Sentiment analysis contains a small gender bias because females tend to express sentiment more explicitly than males online (e.g., Thelwall, in press-b) but this does not affect the current paper much because the main comparisons are between commenters of the same gender, but different targets (MM vs. MF and FF vs. FM).

For each channel and each group (MM, MF, FM, FF), the average positive and negative sentiment strengths of the comments were calculated separately. A 95% confidence interval was calculated for each one using the standard normal distribution formula. This is an approximation since the data is skewed (mode 1 in all cases) and discrete rather than continuous. The data also violates the statistical independence assumption because comments relating to the same video might be influenced by each other. The confidence limits should therefore be interpreted as indicative estimates rather than robust values. Because of this, and for simplicity of analysis of multiple results, differences in average sentiment will be interpreted as significant when confidence intervals do not overlap. This is a compensatory conservative approach because a small overlap between confidence intervals is consistent with statistically significant differences (Schenker & Gentleman, 2001).

3. Results

3.1 RQ1: Presenter gender

The popular science channels mostly had male or mixed presenters, with only a few female presenters. In the mixed cases, males seemed to dominate numerically in all channels. The presenter has varied degrees of prominence in the channels, from being the central visible

figure to being the invisible narrator or, in one case, silent hands. Some channels were animated and some featured guest lecturers, and so not all had a permanent team of presenters.

In terms of the video audience, for all channels there were more male than female commenters. There seems to be no overall relationship between presenter and commenter gender (Table 1). The channel with the highest proportion of male commenters had a female presenter and the channel with the lowest proportion of male commenters had a male presenter, but there are also channels that show opposite patterns (e.g., Computerphile, Explorium). This suggests that engaging a female presenter is not at first glance a good strategy for attracting a female audience for science videos and that the cause of the low female audience is not the dominance of male presenters**.**

Table 1. Descriptive statistics about the 50 selected YouTube science channels, including information about the comments downloaded from them. Channels are listed in descending order of ratio of male to female commenters.

Channel	Presenters	Views (million)	Unique commenters	M/F commenter ratio	M/F commentee ratio
Vintage Space	Female	15	70644	17.4	1.5
Computerphile	Males	60	105204	11.0	39.2
Sixty Symbols	All	64	142415	10.1	11.2
Looking Glass Universe	Female voice	2	8909	10.0	2.1
Periodic Videos	Male	159	151506	8.9	11.6
Deep Astronomy	Male	41	90659	8.6	23.7
Stark Talk Radio	Male	15	35385	8.5	9.3
Universe Today	Male	13	55229	7.8	7.6
Deep Sky Videos	All	8	14586	7.8	3.3
Veritasium	Male	357	505812	7.6	8.6
Science Channel	All	19	53206	7.4	7.9
Allure of Physics	Male	9	4410	6.6	33.5
Space Rip	All voices	141	231138	6.6	12.3
NASA JPL	All	91	61122	6.1	4.6
Minute Physics	Male	322	367254	6.1	20.4
World Science Festival	All	30	28076	5.9	7.3
NASA	All	121	29989	5.8	2.0
Institute of Physics	All	5	2806	5.7	2.1
SmarterEveryDay	Male	379	321796	5.6	9.5
NOVA PBS	All	12	6894	5.6	2.6
Stanford Online	All	3	1409	5.6	3.4
Dr. PhysicsA	Male	15	21204	5.5	35.2
Kurzgesagt	Male voice	244	425470	5.4	6.6
Hubble	All	8	8873	5.4	5.7

Telescope					
Words of The World	All	1	2721	4.9	1.2
Dark Sky Chaser	Male	5	2910	4.8	2.1
BrainCraft	Female	18	46225	4.6	2.2
Physics World	All	2	1014	4.4	7.3
CEN Online	All	2	602	4.2	1.2
Minute Earth	Male-led	124	150401	4.1	3.1
Physics Girl	Female	40	70815	3.9	0.3
Explorium	Female	1	2948	3.9	0.8
Vsauce	Male	1210	1200345	3.8	5.2
It's Okay To Be Smart	Male	90	118943	3.6	5.9
Dnews	All	589	434219	3.4	1.5
Science at NASA	All	39	20703	3.4	5.4
Brusspup	Usually none	526	357655	3.3	6.2
Talks at Google	All	90	30823	3.2	5.1
SciShow	2 m. 1 f.	671	782555	3.2	4.1
Yale Courses	All	54	124	3.0	1.7
TED	All	803	398826	3.0	2.2
Reactions	All voices	26	15864	2.9	1.9
Scientific American	All	15	9454	2.6	2.6
Crash Course	2 m. 2 f.	616	663730	2.4	8.0
Smithsonian	All	5	2312	2.3	0.8
Life Noggin	Male voice	123	339805	2.1	2.8
Khan Academy	Male voices	1146	52794	2.1	20.1
Mental Floss	2 males	171	235734	1.8	3.8
AsapSCIENCE	2 males	785	891508	1.5	2.5
Tyler DeWitt	Male	38	40142	1.0	10.8

There is a broadly linear relationship between the ratio of male to female commenters and the ratio of males to females discussed in a video's comments, although there are outliers. Since pronouns can refer to presenters or other commenters, it is unsurprising that all the labelled outliers in Figure 1 are channels with mono-gender presenters. This suggests that for these channels the presenters themselves are a frequent, but not exclusive, topic of discussion.

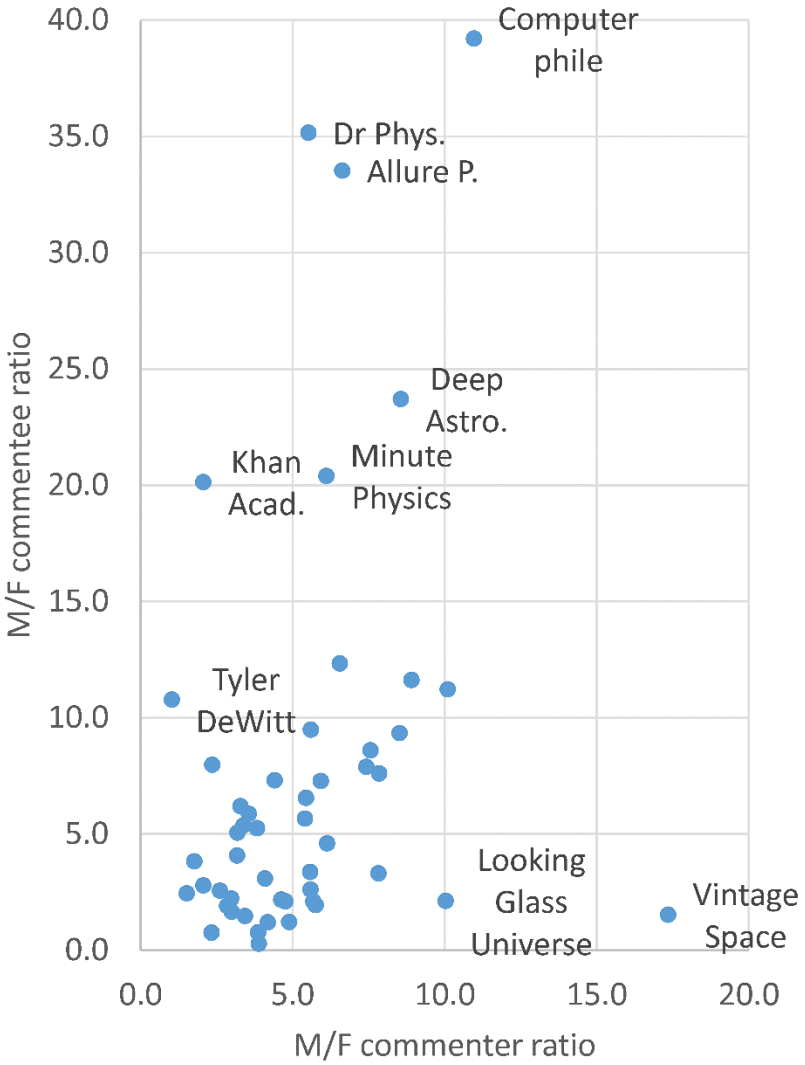

Figure 1. The ratio of male to female commentees (as judged from gendered pronouns) against the ratio of ratio of male to female commenters (as judged by first name) for the 50 selected YouTube science channels. Outliers are labelled. For example, Khan Academy has very many more comments about males than about females (high vertical axis value), but a more equal commenter gender balance (low horizontal axis value, but still above 1).

3.2 RQ2: Commenter sentiment by gender

Taking the presence of a female pronoun and the absence of male pronouns as an indication that the comment is about a female, females tend to comment more positively than males on females in the top 32 (Figure 2a). More specifically:

- The average positive sentiment strength was higher from female than from male authors (FF+ > MF+) in 27 cases in the top 32 channels for comments with only female pronouns (Figure 2a). Ignoring cases where the confidence intervals overlap, the average positive sentiment strength was higher from female than from male authors (FF+ > MF+) in 6 cases (Crash Course, TED, Minute Physics, NASA JPL, Talks at Google, NASA) and the opposite (MF+ < FF+) in no cases. >> **females are more positive than men about females**.
- The average negative sentiment strength was higher from female than from male authors (FF- > MF-) in 22 cases in the top 32 channels for comments with only female pronouns (Figure 2b). Ignoring cases where the confidence intervals overlap, the

average negative sentiment strength was higher for female than for male authors (FF- > MF-) in 2 cases (Vsauce, Dnews) and the opposite (MF- > FF-) in 2 cases (TED, Physics Girl). >> **males and females are equally negative about females**.

- The average positive sentiment strength was higher from female than from male authors (FM+ > MM+) in 24 cases in the top 32 channels for comments with only male pronouns (Figure 2c). Ignoring cases where the confidence intervals overlap, the average positive sentiment strength was higher for female than for male authors (FM+ > MM+) in 7 cases (Vsauce, AsapSCIENCE, SciShow, Dnews, TED, Mental Floss, Talks at Google) and the opposite (MM+ > FM+) in no cases. >> **females are more positive than males about males**.
- The average negative sentiment strength was higher from male than from female authors (MM- > FM-) in 10 cases in the top 32 channels for comments with only male pronouns (Figure 2d). Ignoring cases where the confidence intervals overlap, the average negative sentiment strength was higher for male than for female authors (FM- > MM-) in no cases and the opposite (MM- > FM-) in 7 cases (AsapSCIENCE, SciShow, CrashCourse, Veritasium, Mental Floss, NASA JPL, World Science Festival). >> **males are more negative than females about males**.

Overall, females are more positive than males about everyone and males are more negative than females about males. Recall that females express sentiment a bit more explicitly than males (Thelwall, in press-b), so females might not feel more positive than males but just express their positivity more clearly.

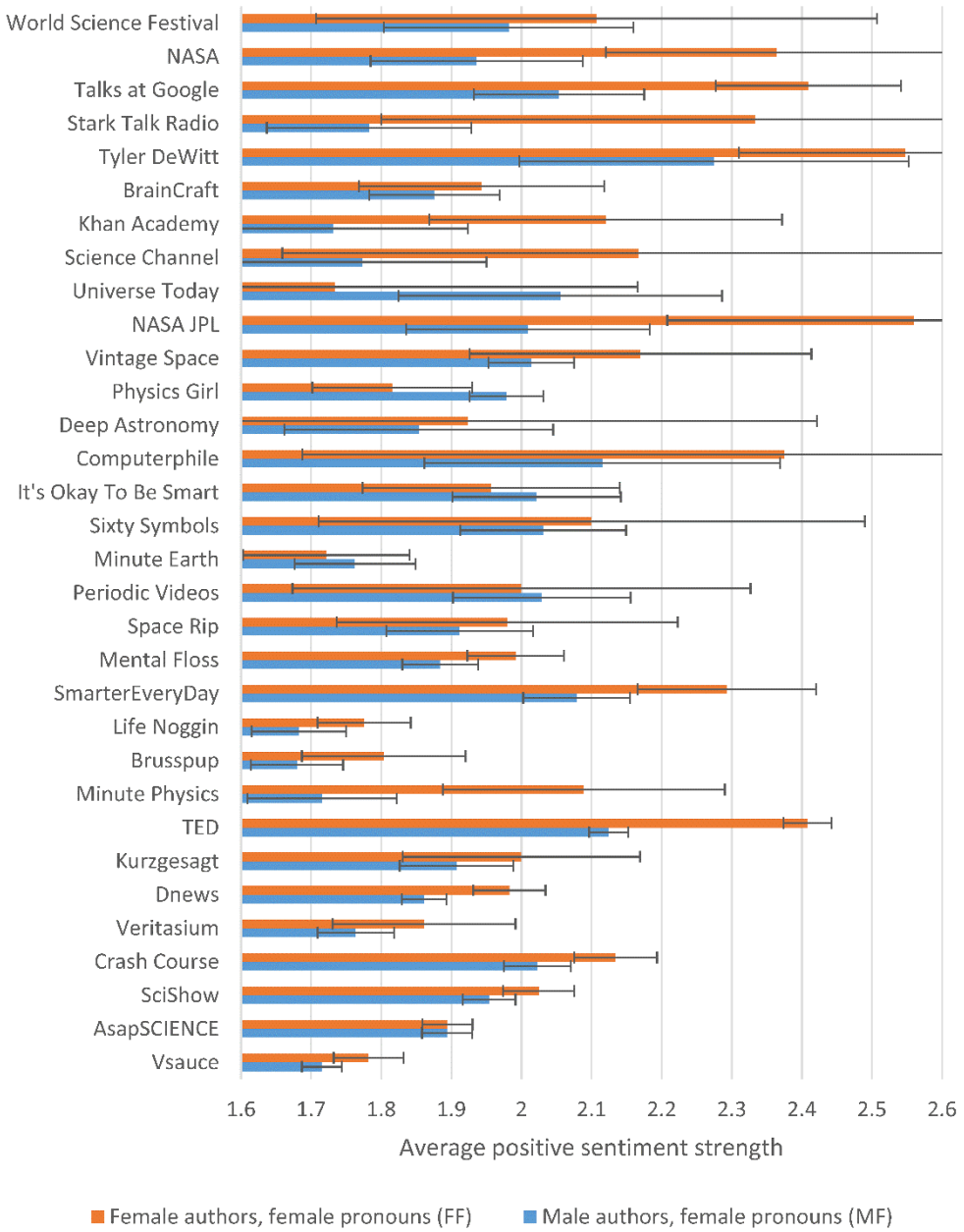

Figure 2a. Average positive sentiment of comments containing female pronouns but no male pronouns, by commenter gender (MF+ FF+) for the 32 YouTube science channels with the most commenters. The predominantly longer FF bars suggest that females tend to be more positive than males about females.

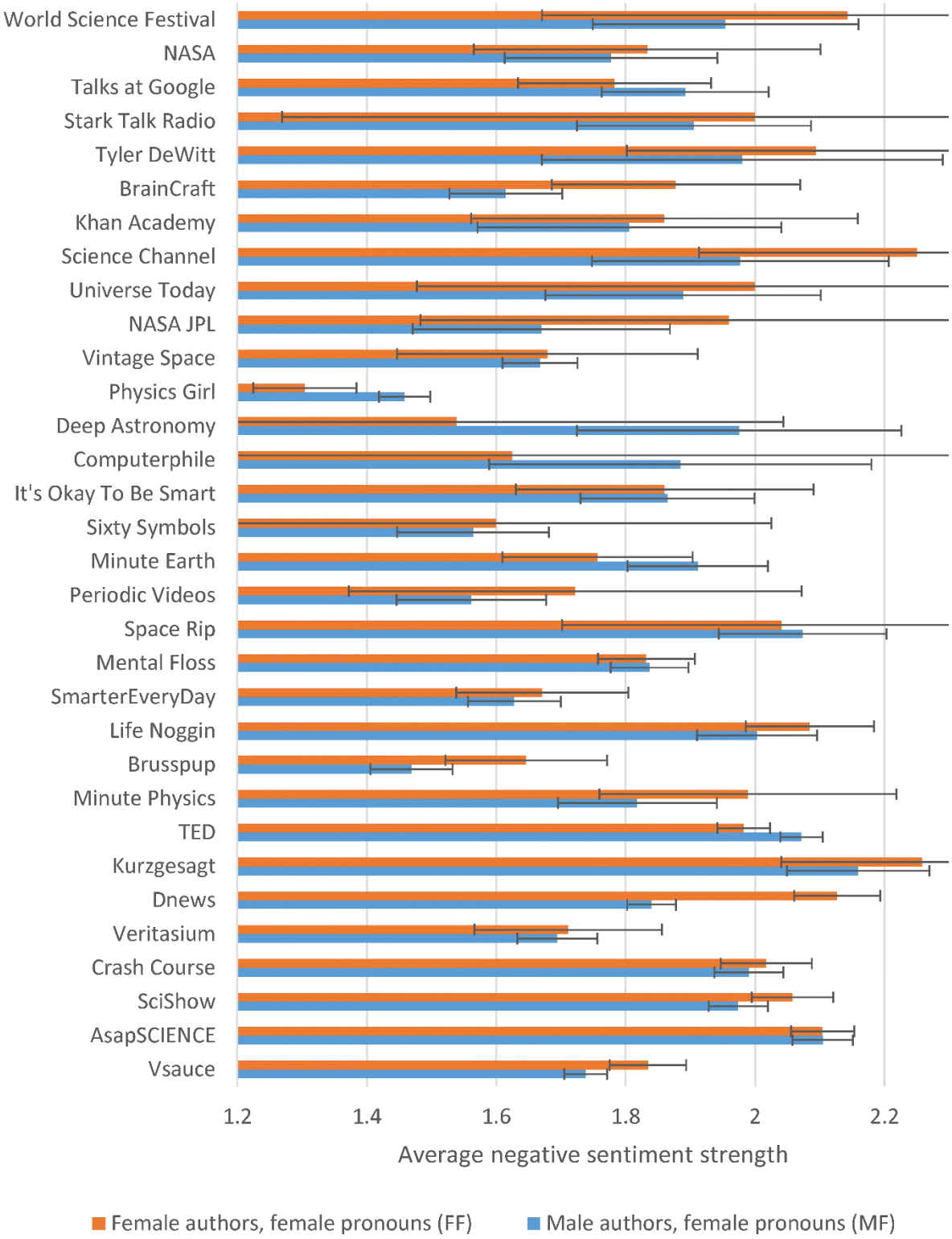

Figure 2b. Average negative sentiment of comments containing female pronouns but no male pronouns, by commenter gender (MF- FF-) for the 32 YouTube science channels with the most commenters. There is not a strong trend in the gender that is most negative about females.

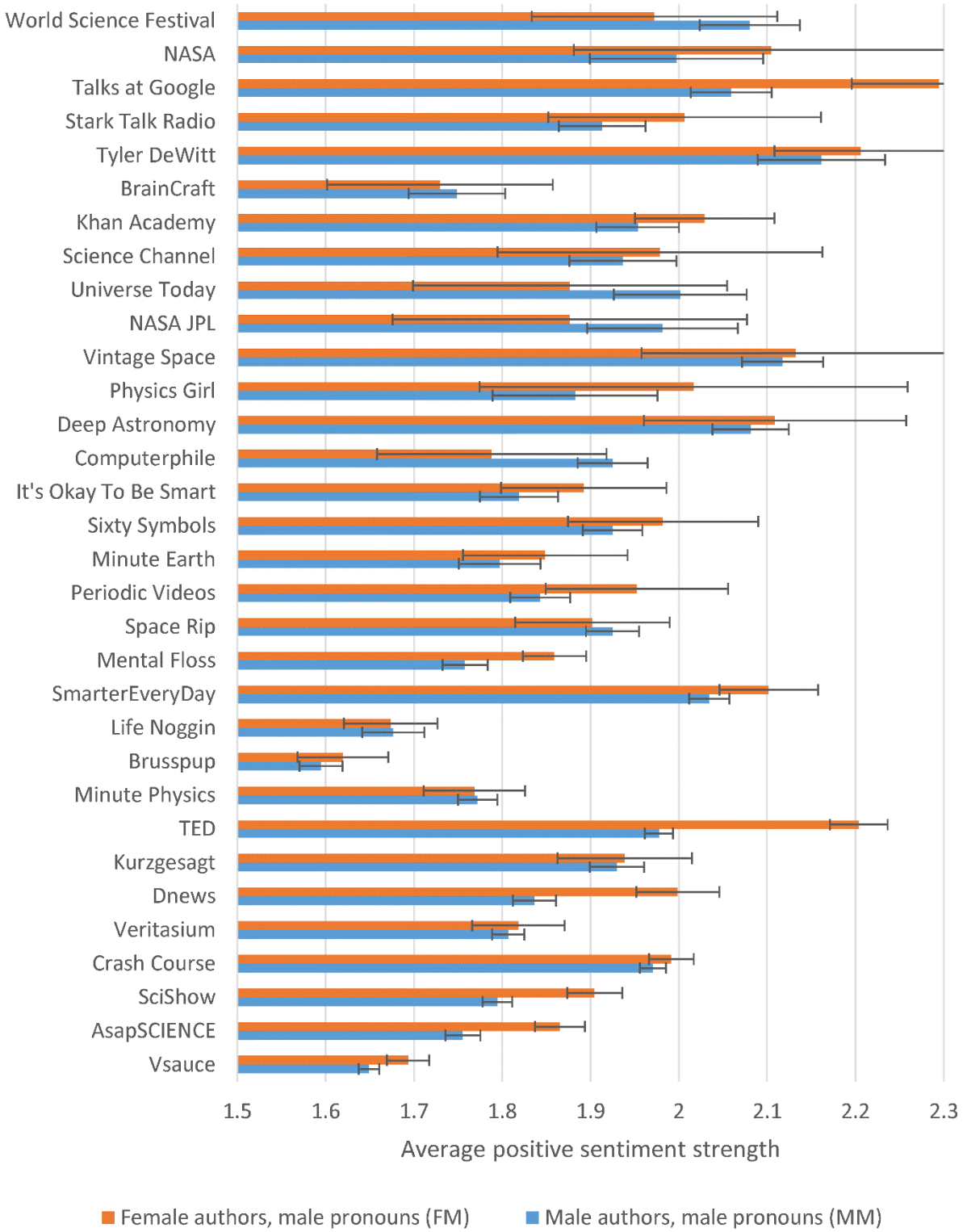

Figure 2c. Average positive sentiment of comments containing male pronouns but no female pronouns, by commenter gender (MM+ FM+) for the 32 YouTube science channels with the most commenters. The predominantly longer FM bars suggest that females tend to be more positive than males about males.

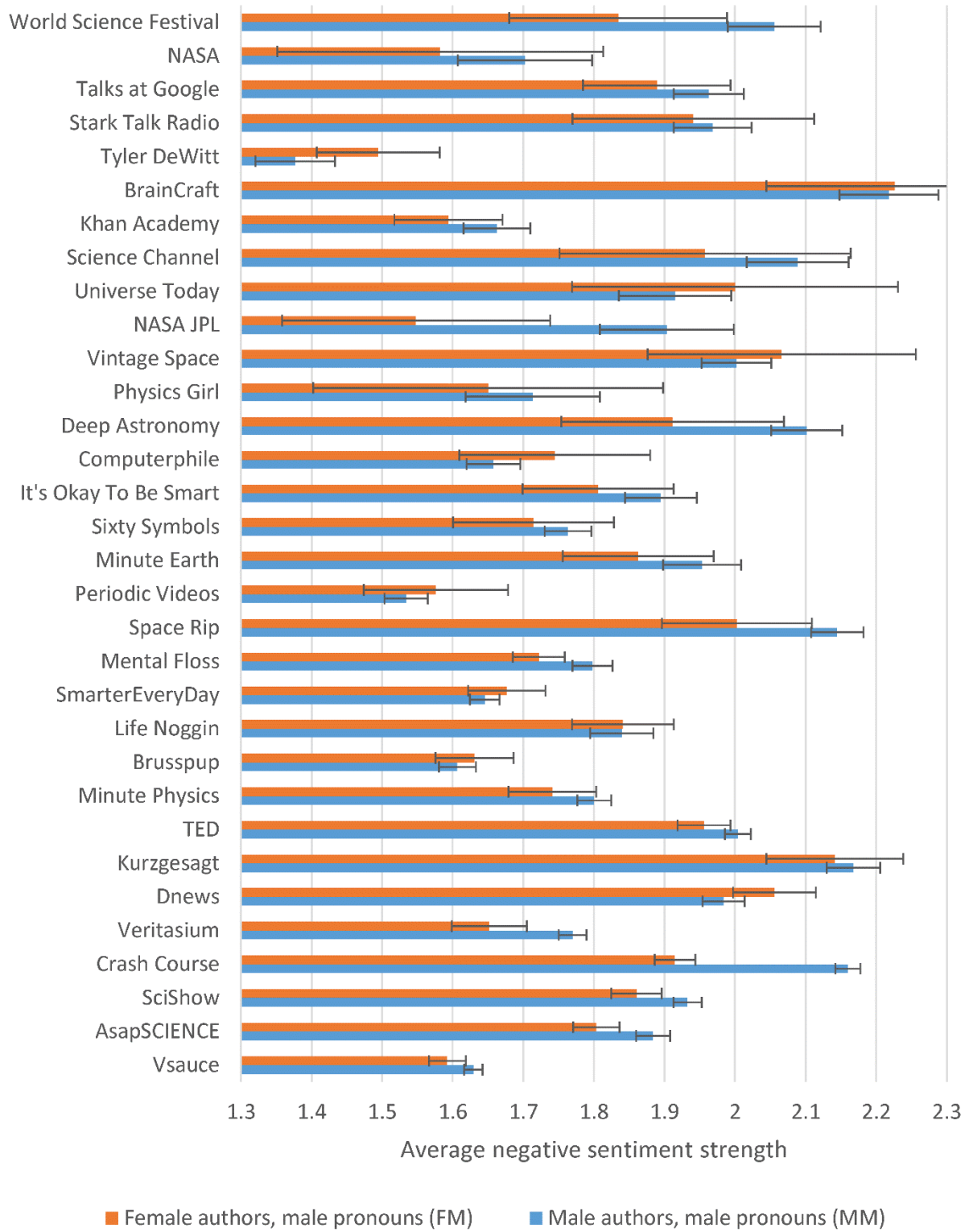

Figure 2d. Average negative sentiment of comments containing male pronouns but no female pronouns, by commenter gender (MM- FM-) for the 32 YouTube science channels with the most commenters. The predominantly longer MM bars suggest that males tend to be more negative than females about males.

Despite the overall sentiment findings, the language used by men towards women could be alienating in more subtle ways. To check for this, for each channel the words in male-authored comments with female pronouns (MF) were compared to the words in female-

authored comments with female pronouns (FF) with a simple word frequency approach to seek systematic differences that might be alienating to women. A difference in proportions z test was used to judge the significance of the difference between the proportion of female-authored and male-authored comments mentioning each term (using Mozdeh's Association mining comparisons tab). Terms were listed in descending order of z value and those with the highest values were examined for evidence of gender bias. Full listings are available here https://figshare.com/s/8c922fc0d30d17b5b1a5.

- The main gendered word was "hot", used almost exclusively by male commenters about females. For example, in BrainCraft, 15 different males and no females used this term, usually in the phrase "she's hot". In Mental Floss, 19 males and 0 females used *hot*. In TED, 79 males and 8 females used *hot* (two females commented "she's hot"). In Crash Course, 25 males and 4 females used *hot*. In Physics Girl, 38 males and 0 females used *hot*.
- In Brusspup, male commenters used *hot* and *ass*, some of which were on a music video with female backing dancers.
- In Talks at Google, 6 males and no females used *fuck*, five as general swear words and one as the sex act (referring to women in general).
- In AsapScience, male commenters used terms like *dick*, *hot*, *sexy* more than females, including on videos with titles, "Does penis size matter?", "36 questions that make strangers fall in love", "Is masturbation good for you" and "Should you shave your pubes". These videos address sex-related issues with evidence from life sciences and psychology.
- In Life Noggin 12 males and 4 females used *hot*, 10 males and 1 female used *feminist*, with the term usually occurring in an insulting context and often in conjunction with swear words.
- DNews has many sexual terms used often by males, including *hot, sexy, cute, crush, tits, marry, beautiful, bang, fucking, boobs, dating*, and *dick*. *Feminist* is also used by males as an insult. The target of the terms is one of the presenters.
- The SciShow video "Why sexy is sexy" presented by a male and supported by abstract graphics attracted many sexual comments from males.
- Male VSauce commenters directed many terms like *hot* and *boobs* to a female guest presenter. Medical terms for genitals were used by 15 males and 1 female commenter in various VSauce videos.

Ironically, female-presented videos may be less conducive to some female viewers. A few male viewers (perhaps children) thought that they had a licence to comment on the attractiveness of female presenters, the stupidity of which may exasperate, alienate, or offend female viewers that read the comments.

4. Limitations

This study has major limitations that affect the ability to generalise the findings. First, YouTube commenters are self-selected and may over-represent the participation of one gender. Males are slightly more likely to comment on videos (Khan, 2017), perhaps being less inhibited in social interactions (Cross, Cyrenne, & Brown, 2013; Rahmani & Lavasani, 2012). A majority of male commenters therefore does not imply a majority of male viewers for a channel, especially if the difference is small. Age and attitude may also influence the likelihood of a viewer posting a comment. These biases may also vary between channels.

The automated method used to detect commenter gender may be more accurate for one gender, which would bias the results.

The study relies upon an indirect method to analyse gender in YouTube: not interviewing or surveying users (which would be very difficult) but harnessing freely available public comments, so may overlook important issues and viewer demographics.

The analysis in this article is also limited by the choice of YouTube channels. Since YouTube claims over 11 million science-related channels, a sample of 50 is small, although the combined video view count of about ten billion might give a substantial minority of the YouTube science audience. The topic mix of the channels is an issue because none focus on the life sciences, where a larger female audience might be expected. One, BrainCraft, has psychology and neuroscience as its focus, however. The channels are all in English and most are from the USA and UK, limiting the generalisability of the results.

The predominantly quantitative approach used here required many simplifying steps and assumptions to be practical and thus may have overlooked some key factors (e.g., gendered phrases) or may have produced misleading information. Moreover, in the absence of qualitative context it is impossible to draw strong conclusions. Most importantly, it is not known how young female scientists react to, or are influenced by, the presence of inappropriate sexualised comments within science videos.

5. Discussion

Presenter gender: The YouTube science channels analysed had few female presenters but male presenters do not, in general, seem to discourage female commenters. Assuming (without evidence) that commenter gender broadly reflects viewer gender or that any gender bias in commenting is constant across channels, this suggests that presenter gender does not greatly influence viewer gender for science channels. Thus, promoting channels with female presenters may not increase the female audience for online science. This is surprising given that contact with female professors generates a positive attitude towards science careers for female undergraduates (Young, Rudman, Buettner, & McLean, 2013), although this varies by discipline (Fried & MacCleave, 2009). More generally, female role models in education (Bettinger & Long, 2005) are also helpful for women. Nevertheless, female role models with personal characteristics that are stereotypical for people that work in their field (e.g., game playing and unfashionable clothes for computer scientists) may have no influence (Cheryan, Siy, Vichayapai, Drury, & Kim, 2011). Thus, part of the value of a female role model may be in showing that it is possible to be successful in science without accepting its predominantly male-generated culture. Perhaps more importantly, since YouTube presenters are geographically remote, their importance as female role models may be less because viewers are less able to interact with them personally and can only see their online persona rather than their wider characteristics. Viewers may also not see YouTube science presenters as potential role models unless the viewer is considering a career in science media. Alternatively, presenter gender may be of relatively minor importance compared to other factors, such as the selection of appropriate topics or the creativity of the presenter to make the content engaging.

The dominance of male presenters for the science channels echoes the situation for other YouTube videos (Ding, Du, Hu, Liu, Wang, Ross, & Ghose, 2011; Lange, 2014; see also: Lenhart, Madden, Rankin Mcgill, & Smith, 2007). Video creation requires computing skills, which interest men more than women (Hargittai & Walejko, 2008; Vedantham, 2011). Although males and females have similar levels of computing skills, females are less

confident (Cai, Fan, & Du, 2017; Hargittai & Walejko, 2008; Li & Kirkup, 2007; Vedantham, 2011; Whitley, 1997), which might limit their aspirations (Correa, 2010). An important motivation for sharing videos online is self-status seeking (Khan, 2017) and the desire for fame (Bughin, 2007), characteristics that are more common for males (Jones, Howe, & Rua, 2000).

Commenter gender: There were more male than female commenters for all the selected science channels, which is consistent with a previous study of the Khan Academy science channel (Saurabh & Sairam, 2013). The apparent male dominance of science channel viewers may partly reflect the greater male use of YouTube (although it varies by topic: Xiao, Zhou, & Wu, 2013). Science videos seem to have a fewer comments than average for YouTube (Siersdorfer, Chelaru, Nejdl, & Pedro, 2010), but the channels analysed in the current study all had extensive commenting and so may be unusual in this regard.

The channels at the top of Table 1 with the highest proportion of male commenters are mainly about space sciences, computers, maths, physics and chemistry, whereas those with the lowest proportion of male commenters are multidisciplinary and some focus on learning, based on courses or educational videos. Male students tend to be more inclined towards the physical sciences and females towards biological sciences (Baram-Tsabari & Yarden, 2011; Jones, Howe, & Rua, 2000). Thus, the physical science topic focus of some channels may be the reason for the low proportion of female viewers. This is not a criticism of the channels for their content because each channel can legitimately decide on a focus to target an audience and expect that audiences requiring other content would find other channels. Nevertheless, a YouTube presenter might realise that their audience is predominantly male and make editorial decisions to appeal to this audience to maximise their revenue. This is the reverse of the strategy used by category romance publishers, for example, ignoring the male market to focus on women (Radway, 1984).

Comment sentiment: The science channel presenters were a frequent, but not exclusive, topic of discussion. Females were more positive than males in comments relating to both males and females, aligning with previous research showing that in social media women express more positive sentiment (Thelwall, Wilkinson, & Uppal, 2010), are friendlier (Kapidzic & Herring, 2011) and give more emotional support (Joiner, Stewart, Beaney, Moon, Maras, Guiller, & Brosnan, 2014). Men may avoid giving emotional support in public, sending private messages instead (e.g., Joiner, Cuprinskaite, Dapkeviciute, Johnson, Gavin, & Brosnan, 2016), and so the public nature of YouTube could supress this behaviour in males.

The greater negativity of males towards males in social media does not seem to have been noticed before in other online contexts, except for one experimental study of text-based interactions that found “mild flaming” to be more likely in male-only online groups (Savicki & Kelley, 2000). In contrast, for example, female celebrities can be disproportionately targeted for online ridicule (Eronen, 2014; see also: Wotanis & McMillan, 2014). In some offline cultures, there is a tradition of banter within male friendship groups that includes exchanging joking insults (Emslie, Hunt, & Lyons, 2013; Kehily & Nayak, 1997; Ward, 2013), which translates to similar online behaviours (Marwick & Boyd, 2014). Some of the male YouTube negativity could therefore be (possibly misguided) attempts at friendliness.

6. Conclusions

Despite the dominance of male presenters amongst the successful YouTube science channels reviewed here, the results do not suggest that redressing this balance would

increase the female audience for science content on individual YouTube channels. Given that attracting a large audience to a YouTube science is likely to be extremely difficult, the (limited) data analysed here suggests that initiatives to attract more women into science should not select this as a goal. If this conclusion is verified by studies with different types of data then this may produce a more nuanced understanding of the contexts in which female role models are helpful in science. It may also produce a deeper understanding of the other factors that influence females in their decision about whether to study science. It would be useful to discover effective strategies for female presenters to transfer online the role model advantage shown by previous research for face-to-face interactions (Young, Rudman, Buettner, & McLean, 2013).

The results do not point to general problems with the attitudes of males commenting on science videos because they show no evidence of male bias against females. The opposite is true because males are apparently more critical than females of males, whereas both are apparently equally critical of females. Nevertheless, a small minority of males post inappropriate sexualised comments about females on YouTube science videos, as exemplified by the term *hot*. Although this is a minority activity, even the knowledge that it does occur for science could be oppressive for videos where it is absent. This *may* be one of the reasons why the male dominance of the YouTube audience is continuing for all types of video combined.

From the lack of negativity towards women in the data it is possible that society (at least on YouTube) has progressed past the stage of thinking – or even joking - that women can't do science, which is a positive outcome. Nevertheless, the continued low level of sexist commenting, particularly on physical characteristics, may well be damaging. It shows that female scientists are still being casually judged for femininity by some, and so have the extra burden of considering their appearance. The presence of this commenting might also encourage women to work in more supportive environments, away from the apparently few juvenile scientists.

Sexist behaviour may be combatted by education about appropriate online behaviour, by comment moderation or through more active policing by the channel owner, YouTube or other users (Potts, 2015) (e.g., clicking the YouTube "Report spam or abuse" button). Education may be effective, since males may not be aware that their behaviour is inappropriate (Thomae & Pina, 2015). Science channel owners should also consider the implications carefully before creating videos that might attract sexualised comments.

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