

Article

Content Analysis From a Gender Perspective of Comments Received by Spanish Science YouTubers

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Submitted: 15 July 2022 | Accepted: 10 January 2023 | Published: 27 March 2023

Abstract

One of the main features of videos that popularise science on YouTube is the ability to interact with the videos and the YouTubers who generate them. However, some types of interaction are often not gender neutral. In order to identify whether there are gender differences in the type of comments posted on YouTube channels that popularise science, a content analysis of nine such channels hosted by Spanish macro influencers was conducted. A total of 221 videos and 18,873 comments were analysed to identify and classify comments of a personal nature relating to physical appearance, tone of voice, or intellectual capacity, among other aspects. The results show that 7.5% (1,424) of the total number of analysed comments were comments of a personal nature addressed to the channel's host. Of the videos hosted by women, 95.3% contained at least one positive comment related to their physical appearance, compared to 27% in the case of men. Gender differences were mainly found in negative comments regarding the presenter's intellectual ability or personality, with women most likely to receive them. These results show that women who face media exposure are more vulnerable to negative sexist comments, which may deter them from professionalisation in this area.

Keywords

gender; science communication; sciencetubers; sentiment analysis; YouTube

Issue

This article is part of the issue “Science Communication in the Digital Age: New Actors, Environments, and Practices” edited by Julia Metag (University of Münster), Florian Wintterlin (University of Münster), and Kira Klinger (University of Münster).

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1. Introduction

Massarani and Moreira (2004, p. 1) follow Raichvarg and Jacques's (1991) idea that the evolution of science popularisation is:

An indispensable complement to the history and philosophy of science, since it raises new questions: Why, for whom and how a science, at a certain moment, was disseminated in the social fabric of an era; which [kind of] people appropriated this science at a given time and by what means.

For García Rizzo and Roussos (2006), in the current context of total transparency of knowledge, it makes sense

that science popularisation—which in natural circumstances would take place among scientists—moves to a more basic and less trained and formal context. It also makes sense for it to be disseminated through non-scientific channels and through a journalistic discourse whose main characteristics are topicality, novelty, veracity, attraction, and public interest (Fontcuberta, 1993). By doing so, scientific communication and journalistic dissemination can complement each other to popularise scientific knowledge (García Rizzo & Roussos, 2006).

Both non-scientific media and mass media have become excellent vehicles for this type of knowledge. In this sense, Buitrago et al. (2022) point to the social enrichment that a collaboration between YouTube outreach and the education sector could generate. This

study focuses on the popularisation of science on YouTube and, specifically, the gender perspective that can be glimpsed from the comments posted by followers.

1.1. Profile of Consumers of Scientific Information Via YouTube

According to the second wave of the General Study of Media (Asociación para la Investigación de Medios de Comunicación, 2021), the internet has a market penetration rate of 84%, and YouTube has a total of 28 million users. Tutorials (74%) and humour videos (53%) make up the most popular content, while scientific content captures the interest of 22% of users (Webedia, 2018). This means that the popularisation of science through YouTube has led to millions of people using these channels as sources of information on science and technology (Fundación Española para la Ciencia y la Tecnología, 2018).

Although its ultimate aim is still to increase knowledge about the findings of the scientific community and to contribute to the creation of an informed and critical citizenry (Davis et al., 2020; Della Giusta et al., 2020), this new format breaks with the rigidity of regular scientific communication and represents a disruptive change in several aspects: firstly, in its use of a more informal language and tone, which allows a greater number of people to engage with science; secondly, in its audio-visual format, halfway between information and entertainment (infotainment style; Davis et al., 2020); and thirdly, in the narrative formulas used, such as storytelling, which aim to provide an answer to a scientific question formulated at the beginning of the video, with a twist during the development of the plot and a final revelation at the end (Huang & Grant, 2020). These features had already been put into practice by conventional media's popularisation of science through the press, radio, or television. But it is on the internet, and specifically on YouTube, where they all converge and have proven effective strategies to increase the impact and popularity of videos among the profile of consumers of popular science content, who are mostly male, aged between 15 and 24, and with a high level of education (EPSCYT, 2018; Velho & Barata, 2020). Hence, if one of the obvious functions of science popularisation is to promote science as a vocation among young students (Calvo Hernando, 1997; Olmedo Estrada, 2011), gender-biased communication will undoubtedly negatively affect future generations (Fernández Beltrán et al., 2019).

In scientific literature, women's lack of interest in consuming such content has been explained from various perspectives, including cultural studies. These studies point to the influence that culture has on how individuals interpret their experiences (McNeil, 2008; Urteaga, 2009). This implies that culture conditions the perception of reality and may explain why arguments such as a negative self-perception of their ability based on social stereotypes (EPSCYT, 2018) and the lack of female refer-

ences in which they can see themselves reflected appear among the reasons given by women for not consuming this type of content (Welbourne & Grant, 2016).

For Villegas-Simón and Navarro (2021), female digital producers who achieve greater recognition on the internet are still linked to typically feminine activities, such as beauty, fashion, or food, which reproduce and perpetuate traditional gender roles, while females continue to make up the majority of the audience for this type of context. Moreover, sexism and male domination continue to be reproduced in the harassment and objectification of women online. Despite the fact that women make up more than half of digital media users, they tend to be represented as consumers and passive subjects, while men tend to be represented as producers and active subjects (Van Zoonen, 2001).

1.2. The Role of Women Producing and Popularising Scientific Content

In addition to pointing to the role of culture in making sense of experiences, cultural studies also point to the conditioning that occurs in the way people act according to norms and stereotypes that are considered correct (Vaast, 2020). The lack of referents, which discourages the consumption of scientific content, may also influence women's interest in producing and popularising said content (Amarasekara & Grant, 2018; Regueira et al., 2020; Velho & Barata, 2020). It has been shown that the occupational preferences of adolescents are often linked to perceptions of gender appropriateness, which are acquired, among other ways, through the representations disseminated by the media (Steinke et al., 2007; Yammine et al., 2018).

In the beginning, social networks were seen as tools that would allow women to access certain jobs that men would have traditionally occupied. This made it possible to create a more democratic space open to perspectives that are usually excluded, although still underrepresented (Loverock & Hart, 2018; Wotanis & McMillan, 2014).

The lack of participation of women as content producers is particularly worrying because this content is consumed primarily by younger people. This may perpetuate a biased view (Amarasekara & Grant, 2018; Velho & Barata, 2020) which would eventually result in maintaining old stereotypes in new media, hinder social progress, and limit access to science for a large number of people (Yammine et al., 2018).

1.3. Interactions With Channels of Popular Science

In addition to the aforementioned particularities, social networks also allow interaction. The bi-directionality of scientific communication on YouTube enables more active participation by the viewers, who may interact with the content of its creators (Davis et al., 2020; Hargittai et al., 2018; Vizcaino-Verdú et al., 2020).

Viewers can express emotions directly or indirectly associated with the scientific debate and generate cognitive and emotional interactions with the content or the YouTuber. This plays a decisive role in promoting greater engagement.

In this sense, it is interesting to distinguish behavioural engagement (which on YouTube would manifest itself through views, likes, dislikes, and comments) from emotional engagement (which seeks, through sentiment analysis or qualitative analysis, to find the meaning of the text in context), and finally, from cognitive engagement (that focuses on the argumentation of replies or the exchange of information to disprove the arguments of the channel host or other users; Dubovi & Tabak, 2021).

From a gender perspective, several studies have focused on reviewing behavioural and emotional engagement depending on the gender of the host of the science popularisation channel. They have shown that this factor can become a disadvantage for women. One of the possible reasons for this is precisely the socio-participatory base on which YouTube operates, which, with a largely male audience, replicates the same ways of interacting and the same problems women face in other areas (Yamine et al., 2018).

The results of some of these studies showed that interactions through comments with the channel host are often not gender neutral, and women are more vulnerable to receiving negative comments about their personality or physical appearance than their male counterparts (da Costa & de Carvalho, 2020; Kitzinger et al., 2008; McDonald et al., 2020; McKinnon & O'Connell, 2020; Velho & Barata, 2020).

Along the same line, the work developed by Amarasekara and Grant (2018) showed that channels hosted by women inspire more participation from viewers (behavioural engagement) but also a large number of negative reactions. These negative comments may take the form of sexist remarks, comments of sexual nature, or statements related to physical appearance (emotional engagement). Likewise, Tsou et al. (2014) and Veletsianos et al. (2018) conclude by stating that when educational or scientific communicators are women, a polarisation of emotional engagement is observed in the responses. They detected that female YouTubers received a greater number of positive and negative comments than male, who received a greater number of neutral comments (Tsou et al., 2014; Veletsianos et al., 2018).

2. Objectives and Hypothesis

The general objective of this article is to compare popular science channels on YouTube hosted by Spanish men and women to identify whether there are differences that could deter women from becoming professional popularisers of science. The specific objectives are:

1. To analyse the presence and content production of science popularisation channels hosted by

Spanish science popularisers (men and women) on YouTube;

2. To explore the frequency of interactions on each of the videos (likes, dislikes, and comments) of all analysed channels;
3. To identify the number of science popularisation videos that contain personal comments addressed to the channel host and to classify them according to the type of comment and their valence.

Based on these objectives, the research hypotheses are as follows:

H1: The participation of Spanish male science popularisers is higher than that of their female counterparts due to the lack of female references in this field.

H2: The way the audience acts according to norms and stereotypes accepted within a society leads to a higher number of interactions (likes, dislikes, and comments) in channels whose scientific communicators are women.

H3: The way the audience acts according to the norms and stereotypes accepted within a society leads to more personal comments (positive and negative) being posted on science communication channels organised by women, thus diverting attention away from the scientific subject matter addressed in the videos.

3. Methodology

First of all, we selected the science popularisation channels, applying the following inclusion criteria: (a) being an active channel (at least one video in the last month), (b) being classified as a popular science channel in the YouTube channel description, and (c) being hosted by a Spanish presenter. In order to make the analysis operative, only the active science popular science channels with the largest audience were chosen as the study sample, which, based on the definition of "macro influencer" determined by Baramidze (2018), are those channels with more than 100,000 subscribers.

The results were extracted on 17 September 2020, and the analysis period was from 1 August 2019 to 31 August 2020. The period was selected to ensure that the data was as up to date as possible and that the videos could have been viewed by a wide audience in a study conducted in 2021.

Once the channels had been identified, and in order to meet Objectives 1 and 2, a content analysis (Krippendorff, 1990) was carried out, taking into account different dimensions associated with: (a) aspects related to the populariser (gender and thematic specialisation of the host of the nine channels found), (b) analysis of the channel (year of creation, number of subscribers, and number of uploaded videos), and (c) quantitative analysis

of the interactions (views, likes, dislikes, and comments obtained in each of the 221 videos found; see Table 1).

Finally, for the identification and classification of possible personal comments, sentiment analysis was carried out using the web scraping software Octoparse. This software collects and exports the comments from each of the videos to Microsoft Excel, thus facilitating the sentiment analysis of the data. Due to the high number of comments in some of the videos, and applying the methodology previously used by Amarasekara and Grant (2018), a maximum of 100 comments per video were selected randomly. To ensure the validity of the sample, the selection was made through Excel's random number generation formulas. This way, a total of 18,873 comments (see Table 1) were read so personal comments could be manually identified and classified. Each comment was single coded for sentiment analysis according to a rubric developed by other authors (Amarasekara & Grant, 2018; Kitzinger et al., 2008; McDonald et al., 2020), making reference to:

1. The YouTuber's physical appearance: Comments either slighting or favourably discussing the physical appearance of the video creator;
2. Their tone of voice: Complimentary or critiquing comments regarding the accent, intonation, or rhythm in the voice of the video creator;
3. Their intellectual capacities: Comments related to the cleverness, intelligence or of the channel's host or offenses related to their intellectual capacity;
4. Their personality: Comments either slighting or favourably discussing the channel host's manner, behaviour, or reactions;
5. Their clothing: Comments either slighting or favourably discussing the way the YouTuber is dressed or how the clothes suit them;
6. The feelings they generate in the viewers: Sexual nature (declarations of love, desire, proposals of marriage or a sexual nature) or hostile comments (statements of hatred, antipathy, or animosity) directed towards the YouTuber.

In turn, each of these personal comments was attributed a valence that allowed us to identify its intentionality (positive or negative) within the context in which it was written. This means that the same word could be classified with positive or negative valence depending on the sender's intention towards the content creator, which can be known from the context in which the word or expression was found.

To avoid inter-observer variation when coding the information, we performed a concordance analysis (Epidat, 2014) on a sample of 20% of the total universe studied, obtaining 94.2% agreement (Carmen Cristófol-Rodríguez and Belén Cambronero-Saiz).

For the statistical analyses, the information was exported to the SPSS programme, version 25. A univariate analysis was performed for the frequency distribu-

tion calculation, while a bivariate analysis was performed for the contingency tables and correlations. The chi-square test was used to interpret the variable cross, with results considered statistically significant when $p \leq 0.05$.

4. Results

Nine popular science channels hosted by Spanish macro influencers were identified, 66.7% hosted by men and 33.3% by women. The women's channels produce considerably fewer videos ($n = 43$ vs. $n = 178$), and all of them were founded more recently (2017–2018; see Table 1).

4.1. Interactions With Popular Science YouTube Channels

Regarding the interactions of the 221 videos analysed, the data shows how, in percentage terms, female YouTubers obtain a higher number of interactions in all indicators, both likes and views (9.2% vs. 8.1%), dislikes and views (0.4% vs. 0.1%), and comments and views (1.1% vs. 0.4%; see Table 2)

By channel, La Gata de Schrödinger has the highest percentage of comments/views (1.3%), followed by La Hiperactina (0.9%) and finally Antroporama (0.5%), which has the same number of comments as the C de Ciencia channel (0.5%; see Table 3).

4.2. Distribution of Personal Comments According to the Type of Comment and Valence

With regard to the appearance of personal comments in the videos, it should be noted that although they accounted for only 7.5% ($n = 1,424$) of the total number of comments analysed ($n = 18,873$), they appeared in 92.3% of the videos ($n = 204$).

The valence of personal comments was mostly positive, accounting for 80.5% ($n = 1,147$), while just 277 were negative. Of these, 21.7% ($n = 309$) were comments related to the YouTuber's physical appearance, 271 with positive valence (PV) and 38 with negative valence (NV), 7.4% were comments related to their tone of voice (PV: $n = 54$; NV: $n = 51$), 17.6% were romantic or hostile statements (PV: $n = 245$; VN: $n = 6$), 31.9% were either flattering or intellectually offensive (VP: $n = 416$; VN: $n = 38$), 12.6% were comments related to personality (VP: $n = 121$; VN: $n = 58$), and lastly, 8.8% were related to clothing (VP: $n = 40$; VN: $n = 86$; see Table 4).

Focusing on the positive comments ($n = 1,147$) and the differences by gender, we see that 65.1% of the personal comments found were addressed to male YouTubers (PV: $n = 722$; NV: $n = 205$) and 34.9% to female YouTubers (PV: $n = 425$; NV: $n = 72$). Most of the positive comments posted on the channels of female popularisers are related to their physical appearance (43.5%) or are romantic declarations (27.3%), while in the case of men, most of the personal comments they receive are intellectual compliments (50.6%) and, to a lesser extent, comments related to their voice (6.4%; see Figure 1).

Table 1. Descriptive information on YouTubers/channels and science popularisation videos on YouTube with more than 100,000 subscribers in 2020.

Channel (year of creation)	Gender of the host	No. of subscribers	No. of uploaded videos (2019–2020)	Views	Likes	Dislikes	Comments
Quantum Fracture (2012)	Male	2,350,000	33	23,472,390	2,072,280	28,484	91,643
CienciadDe Sofá (2012)	Male	314,000	22	5,339,169	392,902	3,894	16,695
C de Ciencia (2014)	Male	1,380,000	33	7,025,656	1,197,418	24,044	69,200
Derivando (2015)	Male	1,040,000	20	6,508,656	430,046	4,913	16,286
Date un Voltio (2015)	Male	893,000	23	3,650,673	292,009	3,446	10,237
Ciencias de la Ciencia (2016)	Male	172,000	47	1,327,391	55,296	1,099	6,257
Antroporama (2017)	Female	542,000	6	1,936,308	205,285	1,574	8,772
La Hiperactina (2018)	Female	176,000	9	1,020,329	120,673	1,129	8,652
La Gata de Schrödinger (2018)	Female	457,000	28	6,802,817	576,654	32,752	94,017

Table 2. Percentage of views vs. likes, dislikes, and comments by gender (2019–2020).

Gender of the YouTuber/views (<i>n</i>)	Likes/views (<i>n</i>)	Dislikes/views (<i>n</i>)	Comments/views (<i>n</i>)
Females (<i>n</i> = 9,759,454)	9.2% (<i>n</i> = 902,612)	0.4% (<i>n</i> = 35,455)	1.1% (<i>n</i> = 111,441)
Males (<i>n</i> = 55,321,309)	8.1% (<i>n</i> = 4,439,951)	0.1% (<i>n</i> = 65,880)	0.4% (<i>n</i> = 207,617)

Table 3. Percentage of views vs. likes, dislikes, and comments per channel (2019–2020).

Channel/views (<i>n</i>)	Likes/views (<i>n</i>)	Dislikes/views (<i>n</i>)	Comments/views (<i>n</i>)
La Hiperactina (<i>n</i> = 1,020,329)	11.8% (<i>n</i> = 120,673)	0.1% (<i>n</i> = 1,129)	0.9% (<i>n</i> = 8,652)
Antroporama (<i>n</i> = 1,936,308)	10.6% (<i>n</i> = 205,285)	0.1% (<i>n</i> = 1,574)	0.5% (<i>n</i> = 8,772)
Quantum Fracture (<i>n</i> = 23,472,390)	8.8% (<i>n</i> = 2,072,280)	0.1% (<i>n</i> = 28,484)	0.4% (<i>n</i> = 91,643)
La Gata de Schrödinger (<i>n</i> = 6,802,817)	8.5% (<i>n</i> = 576,654)	0.5% (<i>n</i> = 32,752)	1.3% (<i>n</i> = 94,017)
C de Ciencia (<i>n</i> = 14,720,912)	8.1% (<i>n</i> = 1,197,418)	0.2% (<i>n</i> = 24,044)	0.5% (<i>n</i> = 69,200)
Date un Voltio (<i>n</i> = 3,650,673)	8.1% (<i>n</i> = 292,009)	0.1% (<i>n</i> = 3,446)	0.3% (<i>n</i> = 10,237)
Ciencia de Sofa (<i>n</i> = 5,339,169)	7.4% (<i>n</i> = 392,902)	0.1% (<i>n</i> = 3,894)	0.3% (<i>n</i> = 16,695)
Derivando (<i>n</i> = 6,508,656)	6.6% (<i>n</i> = 430,046)	0.1% (<i>n</i> = 4,913)	0.3% (<i>n</i> = 16,286)
Ciencias de la Ciencia (<i>n</i> = 1,629,509)	5.1% (<i>n</i> = 55,296)	0.1% (<i>n</i> = 1,099)	0.4% (<i>n</i> = 3,556)

Table 4. Personal comments and valences identified in the science popularisation videos disseminated through YouTube (2019–2020).













Personal comment and description		Valence examples
<p><i>Physical appearance</i></p> <p>(+) Appearance-related comments, such as compliments on a YouTuber’s physical appearance</p> <p>(–) Negative comments related to the physical appearance of the YouTuber</p>	<p>Positive</p> <p>Negative</p>	<p> MaxKeenti hace 2 años 54 suscriptores ¿Soy yo o este hombre debería ser modelo?, le admiro mucho por su impresionante habilidad de la comunicación científica y esa es la razón por la que le sigo, pero con cada vídeo pienso en lo guapo que es.</p> <p>Is it just me, or should this man be a model? I admire him a lot for his impressive scientific communication skills, and that’s the reason I follow him, but with every video, I think how handsome he is.</p> <hr/> <p> ampax420 hace 1 año Amigo, afeitate para el video por lo menos no?</p> <p>Dude, shave for this video at least, no?</p>
<p><i>Voice</i></p> <p>(+) Compliments related to the YouTuber’s accent, voice volume, musicality, expressions, or intonation</p> <p>(–) Comments related to low voice volume, wrong expressions, or poor intonation</p>	<p>Positive</p> <p>Negative</p>	<p> Angel Alvarez hace 2 años Vamos sube videos que mi mente se saca junto con mis oídos por no poder escuchar tu hermosa voz xd</p> <p>Come on, upload videos, my mind is racing, and my ears are pounding from not being able to hear your beautiful voice.</p> <hr/> <p> Wikii Lokii hace 1 año Madre mía qué voz más monótona y aburrida. 🙄</p> <p>My goodness, what a monotonous and boring voice!</p>
<p><i>Feelings</i></p> <p>(+) Declarations of love, desire, proposals of marriage, or comments of a sexual nature</p> <p>(–) Statements of hatred, antipathy, or animosity towards the YouTuber</p>	<p>Positive</p> <p>Negative</p>	<p> TheBlackFlame hace 1 año Cuando Rocío te parece ya de por sí extremadamente sexy (por los labios y la sonrisa) y... 9:57.</p> <p>When Rocío is already extremely sexy (because of her lips and smile) and...</p> <hr/> <p> Francisco Advis hace 1 año Chica, lo siento no me gustaste.</p> <p>Girl, I’m sorry, I didn’t like you.</p>
<p><i>Intellect</i></p> <p>(+) Comments related to the cleverness, intelligence, talent, insight, or wit of the channel’s host</p> <p>(–) Insults or offenses related to their intellectual capacity</p>	<p>Positive</p> <p>Negative</p>	<p> Aleidy Bremón hace 1 año 33 suscriptores Wao, que hombre más sabio... 🤔👍</p> <p>Wow what a wise man...</p> <hr/> <p> Eusebio gallardo martin hace 2 años PROFESOR NO HAS DADO UN PALO AL AGUA EN TU PROFESION SOLO VIVES DE LO QUE HAS ESTUDIADO AHORA SE QUE TE PAGAN PARA DESMANTELAR IDEAS PERO GANAS UNA BUENA PASTA ME ALEGRO POR TI PERO NO SEAS HIPOCRITA CON EL RESTO</p> <p>Professor, you “have not lift a finger” in your profession, you only live on what you have studied. Now, I know you are paid to dismantle ideas but you earn a good paste. I am happy for you but do not be hypocritical with the rest.</p>
<p>Personal comment and description</p>		<p>Valence examples</p>
<p><i>Personality</i></p> <p>(+) Comments related to the channel host’s manner, behaviour, or reactions</p> <p>(–) Negative comments related to the YouTuber’s personality (e.g., provocative, misrepresentative)</p>	<p>Positive</p> <p>Negative</p>	<p> Mr White hace 1 año 15 suscriptores 3:40 te has comido un 7 genio</p> <p>You ate a 7, genius.</p> <hr/> <p> OA BM hace 1 año Que aburrido</p> <p>How boring.</p>

Table 4. (Cont.) Personal comments and valences identified in the science popularisation videos disseminated through YouTube (2019–2020).

Clothing	
(+) Complimentary comments related to the way the YouTuber is dressed or how well the clothes suit them	<p>Positive</p> <div style="border: 1px solid #ccc; padding: 5px; margin-bottom: 5px;">  <p>Juan Benotto hace 1 año Quiero esa remeraaaa. Viene con vos? Jajaja</p> </div> <p>I want that t-shirt. Does it come with you? Hahaha.</p>
(-) Negative statements related to the clothes worn by the YouTuber or how bad a certain piece of clothing looks on him/her	<p>Negative</p> <div style="border: 1px solid #ccc; padding: 5px;">  <p>antxon urrutia urrutia hace 1 año Te queda la camiseta un poco prieta...</p> </div> <p>The t-shirt is a bit tight...</p>

4.3. Distribution of Personal Comments on Videos

Regarding the distribution of comments per video, it is observed that 95.3% of the videos conducted by women contained at least one positive comment related to their physical appearance, compared to 27% in the case of men (see Table 5).

This same difference by gender is also observed in the love declarations, as 88.4% of the videos uploaded by women have at least one such comment, and only 33.7% in the case of the videos uploaded by men ($\chi^2 = 41,933$; $p = 0.000$). Among the positive comments, intellectual compliments are also very frequent, being present on 71.5% of the videos, with no statistically significant differences by gender between the number of videos that include at least one intellectual compliment. In the case of men, the positive comments focus much more on clothing, with statistically significant differences to the videos conducted by women when the chi-square test was applied ($\chi^2 = 5.758a$; $p = 0.016$; see Table 5).

On the other hand, despite the fact that few videos have negative comments, differences by gender have also been detected in the probability that a video hosted by a woman receives negative comments related to her

intellectual capacity ($\chi^2 = 13.058a$; $p = 0.000$) or her personality ($\chi^2 = 50.893a$; $p = 0.000$; see Table 6). In the case of men, the most frequent negative personal comments are those related to their voice, which appear in 12.9% of the cases, compared to 2.3% in the case of women communicators ($\chi^2 = 4.017a$; $p = 0.045$; see Table 5).

In general terms, the words that appear most frequently are *guapa* (pretty) and its derivatives or synonyms (*hermosa*, which means beautiful), as well as expressions of love. Adjectives related to the channel host’s intellectual capacity are also frequently mentioned through adjectives such as *crack* (ace), *genio* (genius), *grande* (great), or *inteligente* (intelligent), or their way of being, through terms such as *bueno/buena* (good) or *encantador/encantadora* (charming).

5. Discussion

The study’s results indicate that there is a lower number of female Spanish science communicators on YouTube. This confirms the study’s first hypothesis, which is based on the premise that women are underrepresented on this social network, much like in mass media. As cultural studies point out, the lack of female representation

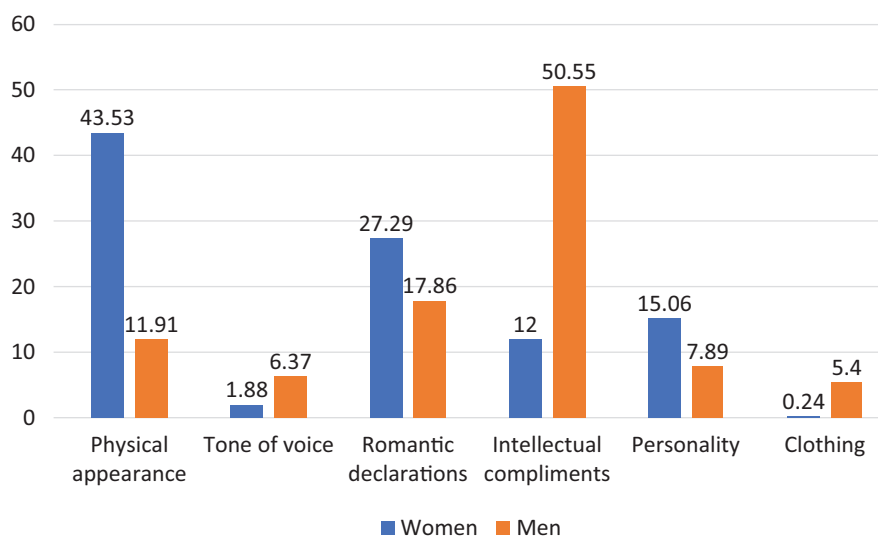


Figure 1. Differences by gender in the positive personal comments in science popularisation videos (%).

Table 5. Popular science videos in which positive and negative personal comments are posted, differentiated by the gender of the YouTuber (with respect to the total 221 videos).

Comments	Valence (+/-)	Videos by women (N = 43)		Videos by men (N = 178)		χ^2	df	p
		n	%	n	%			
Physical appearance	+	41	95.3	48	27.0	67.330	1	0.000
Tone of voice	+	6	14.0	24	13.5	0.007	1	0.936
Romantic declarations	+	38	88.4	60	33.7	41.933	1	0.000
Intellectual compliments	+	29	67.4	129	72.5	0.430	1	0.512
Personality	+	34	79.1	38	21.3	52.534	1	0.000
Clothing	+	1	2.3	29	16.3	5.758	1	0.016
Physical appearance	-	8	18.6	16	9.0	3.308	1	0.069
Tone of voice	-	1	2.3	23	12.9	4.017	1	0.045
Hatred statements	-	1	2.3	5	2.8	0.031	1	0.861
Intellectual affronts	-	14	32.6	19	10.7	13.058	1	0.000
Personality	-	21	48.8	11	6.2	50.893	1	0.000
Clothing	-	3	7.0	24	13.5	1.367	1	0.242

Notes: $p < 0.05$.

in the field may mark the occupational preferences of adolescent girls linked to the perception of gender appropriateness.

Despite the fact that macro influencers own all the channels studied, there are notable variations by gender in absolute terms of subscribers and views, both of which are key indicators for positioning on this social network (Google, 2023). One of the possible causes is the late incorporation of women into the popularisation of scientific content through YouTube, which also directly impacts the lower levels of content production observed in this study. This implies that their male colleagues' channels are also more likely to be better positioned since they have been active for longer.

However, it should also be noted that the popularity of the channel may be influenced by the charisma or personality of the YouTuber, as well as, among other reasons, the topics covered, the approaches presented, collaborations with other YouTubers, their appearance in conventional media, and the use of other social networks that redirect users to YouTube channels. In turn, these perceptions may be conditioned by the channel owner's fit with gender stereotypes. The lack of correspondence with traditional female stereotypes may provoke rejection among some viewers. This is reinforced by the higher percentage of negative comments towards women about their personalities (Döring & Mohseni, 2019, 2020).

Our results also confirm the second hypothesis since, in terms of relative frequencies, the three popular science YouTube channels hosted by Spanish female macro influencers have a higher number of interactions than those hosted by men, coinciding with the results

obtained in previous studies conducted in different countries (Tsou et al., 2014; Veletsianos et al., 2018).

This is true both for positive interactions (measured in likes/views), negative interactions (dislikes/views), and the number of comments (comments/views). This can lead to greater emotional engagement on the part of the viewers, which could be the basis for generating greater involvement in the scientific debate. The importance of emotional engagement, expressed through positive or negative emotions, stands out as a determining element for generating trends in posting comments, and even for triggering behavioural and cognitive engagement that leads to more in-depth interventions (Dubovi & Tabak, 2021).

Finally, the third hypothesis is confirmed, as it shows that popular science YouTube channels hosted by women produce, in relative terms, a greater number of both positive and negative personal comments. Thus, personal comments towards women are usually related to the YouTuber's physical appearance, mostly in the form of compliments or romantic declarations, which does not happen with the same frequency in the case of men. As pointed out at the beginning, two factors that may explain this behaviour are, firstly, the mostly male audience of popular science channels and, secondly, the socio-participatory base of the social network. Both factors contribute to replicating the same behaviours in accordance with the norms and stereotypes considered correct and acceptable in society (Yamine et al., 2018).

These interventions contribute to the promotion of gender stereotypes, the perpetuation of the objectification of women, their being discredited as experts or specialists in the subject matter, and the lowering of

their credibility or authority to generate knowledge and discussion about a topic since, as some authors have pointed out before, the nature and tone of the comments influence the audience's perceptions of the quality of the video content (Amarasekara & Grant, 2018). In addition, the fear of being judged by factors unrelated to the content has led many women who make popular science videos to emphasise their legitimacy, taking care of aspects such as clothing or the topics to be covered, avoiding those that could provoke sexual or sexist comments (McDonald et al., 2020). The increased number of negative emotional responses, sometimes unrelated to the topic of discussion, can also have a deterrent effect on the professionalisation of women as science communicators, as it can affect the credibility or popularity of a channel (EIGE, 2020). This contributes to reinforcing the Matilda effect, in which women scientists suffer underestimation and insufficient and systematic recognition of their work (Reif et al., 2020), leading to a lower number of subscribers, a lower channel impact, and less visibility.

In the case of men, an opposite trend is detected, as the frequency of positive personal comments is focused not so much on physical praise but intellectual praise.

The main novelty of this work lies in incorporating the gender perspective in the analysis of the comments of scientific communicators through online communication channels. Although similar works had already been carried out internationally, this is the first work of this type in Spain. Among the main results, the verification that sexist behaviours continue to be repeated in the new communication channels stands out. Specifically, our results show that women who face media exposure are more vulnerable to negative sexist comments, which may deter them from professionalisation in this area.

Despite the differences detected, it is important to highlight that only 7.5% of the videos studied have personal comments, which shows that only a minority of viewers make this type of intervention. As a line of future research, it would be interesting to study and classify all the comments in order to determine their pertinence or relevance to the topic addressed in the video analysed.

It should also be taken into consideration that one of the main limitations of the study is the bias of YouTube's recommendation algorithms, which can benefit the visibility of certain videos and perpetuate the position of the most consolidated channels, as well as encourage the recommendation of gender-biased content (Bishop, 2018). Furthermore, we have not considered the socio-demographic variables of the viewers related to gender, age, or educational level that can shed new light on the topic of study. One limitation of the study is that it did not consider the potential ideological biases of the YouTube content creators, which may arise due to their own political and ideological stances and could lead to controversies outside the scientific debate. This implies that the comments may not only be conditioned by the video's content but also by the very approach with which the YouTuber talks about the content. Also,

the study's results may vary over time since the channels studied are still active and, therefore, interactions with the videos can continue to be made. Finally, as the methodology used had not been previously tested, there may be important categories that had not been taken into account by this article.

6. Conclusions

The under-representation of women in popular science also persists in social networks such as YouTube. This implies that the barriers to participation come not only from factors specific to the work field, such as the glass ceiling, but may also be the result of the internalisation of socially shared values and beliefs that serve as the basis for the social construction of reality. These ideas can also be reinforced through the personal comments to which women are exposed. Stereotypical evaluations, which emphasise aspects traditionally valued more in one gender than in the other, such as beauty in the case of women and intellectual capacity in the case of men, show that critical media education is necessary to continue fighting against gender stereotypes.

Although the higher number of interactions with female-hosted channels may contribute to strengthening the audience's commitment to the scientific debate, it is also true that if these interactions have an NV, they can be a deterrent to women's professionalisation as communicators, as they might rather not be exposed to value judgments that are unrelated to the scientific debate.

Acknowledgments

I would like to thank Sukhi Lubana for his help with data export and statistical data processing.

Conflict of Interests

The authors declare no conflict of interests.

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