Article

Pro-Science, Anti-Science and Neutral Science in Online Videos on Climate Change, Vaccines and Nanotechnology

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Abstract

Online video has become a relevant tool to disseminate scientific information to the public. However, in this arena, science coexists with non-scientific or pseudoscientific beliefs that can influence people's knowledge, attitudes, and behavior. Our research sets out to find empirical evidence of the representation of pro-science, anti-science and neutral stances in online videos. From a search on Google videos, we conducted content analysis of a sample of videos about climate change, vaccines and nanotechnology (n = 826). Results indicate that a search through Google videos provides a relatively small representation of videos with an anti-science stance, which can be regarded as positive, given the high potential influence of this search engine in spreading scientific information among the public. Our research also provides empirical evidence of the fact that an anti-science stance is more frequent in user-generated content than in videos disseminated by other types of producers.

Issue

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1. Introduction

In recent years, terminology seeking to classify messages that are favorable or contrary to established scientific knowledge have proliferated. In relation to anti-science stance messages, terms such as 'misinformation,' 'disinformation,' 'fake news' and 'denialism' are applied. On the other hand, 'science advocacy' and 'pro-science' are employed to promote a stronger role of science in society. Neither positive nor negative, 'neutral science' and related words are simply descriptive and explanatory. It is not our intention to discuss or delimit these terms. Prior work has been done by other authors in this regard (e.g., Gerasimova, 2018; Lazer et al., 2018; Scheufele & Krause, 2019).

In this article, we use the terms 'pro-science,' 'anti-science,' and 'neutral science' broadly, covering all related words. We use 'pro-science' to express active support for established scientific knowledge; 'neutral science' as an expression neither in support or against established scientific knowledge, and 'anti-science' as contrary to established scientific knowledge.

Our goal is to better understand how much pro-science, anti-science and neutral science messages circulate in videos returned by Google search results and who exactly are the people responsible for producing these videos in relation to three selected topics: climate change, vaccines, and nanotechnology. Finally, we analyze scientists' voices in a sample of videos.

2. Literature Review

2.1. Pro-Science vs. Anti-Science

Science coexists with non-scientific or pseudoscientific beliefs that influence people's knowledge, attitudes, and behavior. In the Internet era, citizens' search for scientific information based on preexisting beliefs and values (Yeo, Cacciatore, & Scheufele, 2015), plus the difficulty of recognizing inaccurate information (Lazer et al., 2018), may result in an increasing number of misinformed citizens.

According to Schmid and Betsch (2019), anti-science messages resort to false experts, appeal to conspiracies, ask for the impossible (e.g., 100% vaccine safety), create false dilemmas or biased selections of data. In these cases, the authors point out that, in order to avoid misleading information, it is necessary to fight back with immediate responses. We argue that this can be applied to respond to anti-science with pro-science claims.

Non-scientific and beliefs do not arise from all scientific topics. Consequently, there are some topics that cause hardly any anti-science messages to be produced while other topics provoke manifold and widely spread anti-science messages. It is precisely those scientific issues polarizing society that generate a large number of anti-science and pro-science messages. Climate change is a perfect example.

There is overwhelming scientific consensus on climate change (Carlton, Perry-Hill, Huber, & Prokopy, 2015; Cook et al., 2013). However, the discussion about its very existence, causes and consequences, remains within the purview of non-scientific forums. Petersen, Vincent and Westerling (2019) found that the visibility in press articles of those who deny climate change was 49% higher than that of those who believe in it. Even in *The New York Times*, *The Guardian* or *The Wall Street Journal*, contrarians were cited slightly more often than those who represented scientific consensus. The role of media in the journalistic coverage of climate change has been studied from the perspective of balance, a journalistic routine that seeks neutrality regarding controversial issues, but one that in this case has led to greater visibility of anti-science positions (Boykoff, 2007).

In online media, during the US presidential campaign and subsequent election, Donald Trump was the top influencer on global warming, significantly increasing the presence of skeptical discourse on climate change (Swain, 2017). Conversely, the youth movement initiated by Greta Thunberg, namely Fridays for Future, has contributed to a call to action to address climate change in worldwide media (Boykoff et al., 2019).

Although less present in the global political arena, vaccines are yet another scientific topic that produces a vast number of both anti-science and pro-science messages. Vaccines have largely been shown to be effective. Nevertheless, some parents still refuse to have their children vaccinated, basing their decision on different reasons: religious/philosophical or personal beliefs, safety concerns, and a desire for further information (McKee & Bohannon, 2016).

The most emblematic case of anti-science stance in the field of vaccines was that of the measles–mumps–rubella vaccine. A study published in the late 1990s hypothesizing a link between measles–mumps–rubella vaccination and autism (Wakefield et al., 1998) contributed to a significant boost of the anti-vaccination movement. Though the medical journal that published this article later retracted, the idea had already penetrated many people's minds through the media, which for many years have continued to spread this supposed relationship between measles–mumps–rubella, vaccination and autism (Dixon & Clarke, 2013). Indeed, Hoffman et al. (2019, p. 2216) have recently found that "social media outlets may facilitate anti-vaccination connections and organization by facilitating the diffusion of centuries old arguments and techniques."

Many papers analyze anti-vaccine movements, but the literature on pro-vaccine activism is sparse. In fact, a variety of pro-vaccine activism groups have been shown to focus, to a greater or lesser extent, and in diverse ways, on the political and media debate (Vanderslott, 2019).

Pro- or anti-nanotechnology movements exist but they do not have a prominent social impact. Little evidence is found of political or religious polarization regarding nanotechnology (Drummond & Fischhoff, 2017). This young science is controversial on issues such as stem-cell research and genetic modification of human beings; impacts on human life, family and social structures; or the creation of artificial intelligences (Sandler, 2009; Scheufele & Lewenstein, 2005). However, in the public sphere, nanotechnology is currently not as questioned as climate change or vaccines (Erviti, Azevedo, & Codina, 2018). Fragmented and ambiguous media portrayals of nanotechnology may actually mitigate its risks (Boholm & Larsson, 2019).

2.2. Online Videos

One of the types of content that grows faster in Internet traffic is video (Cisco, 2019). Editing a scientific video implies a greater effort than publishing a post or a tweet, and can also imply greater intentionality; besides, its high potential impact has made video a key tool to distribute scientific information to the public (León & Bourk, 2018). The problem is that the dynamics of online circulation of videos may be favoring misinformation, even more so when, in topics such as climate change, deniers and skeptics participate more actively than pro-science people in social media (Arlt, Hoppe, Schmitt, De Silva-Schmidt, & Brüggemann, 2018).

The video platform most analyzed by academics is YouTube. It was created in 2005 and it was purchased by Google the following year, 2006. Unfortunately, different studies on YouTube's recommendation algorithm indicate that it promotes what we call anti-science. For

the selected topics for this research, we find the following conclusions:

In relation to climate change, YouTube videos support worldviews that to a large extent oppose scientific consensus (Allgaier, 2019). This platform promotes and recommends denialist and anti-scientific videos, including conspiracies and false theories about climate change. Some of these videos accumulate hundreds of thousands of views (Avaaz, 2020).

Vaccine videos have been more frequently studied than climate change videos. Venkatraman, Garg, and Kumar (2015, p. 1422) claimed that "online communities with greater freedom of speech lead to a dominance of anti-vaccine voices," so the level of freedom of online speech correlates with the level of misinformation about vaccines. According to their results, support for a link between vaccines and autism is most prominent on YouTube, followed by Google search results. Other authors confirm this view with their studies on YouTube videos: Song and Gruzd (2017), for example, concluded that 65.02% of the videos were anti-vaccine, 20.87% were pro-vaccine, and 14.11% were neutral. Ekram, Debiec, Pumper, and Moreno (2019) discovered that the anti-vaccine ideology was prevalent in video content and commentary, containing erroneous and incomplete information. Moreover, anti-immunization content is generally favored over pro-immunization content (Yiannakoulias, Slavik, & Chase, 2019).

There are no published studies regarding nanotechnology on YouTube. In any case, the good news is that YouTube video platform recommendations leading to content with conspiracy theories have been reduced by 40% as of April 2019, due to changes in its algorithm (Faddoul, Chaslot, & Farid, 2020).

While YouTube amplifies "sensational content because of its tendency to generate more engagement" (Faddoul et al., 2020, p. 1), Google is a different search engine that prioritizes quality (DiSilvestro, 2017) and tries to avoid misinformation (Del Vicario et al., 2016). Unlike YouTube, Google is not a video platform, so searches on Google videos display links to websites which algorithm detects a hosted video. In the case of YouTube, search results directly show videos. For these reasons, the use of YouTube and Google is usually for different purposes: Google is most often used as a tool for finding information, YouTube for entertainment. However, many Google search results link to YouTube videos (DiSilvestro, 2017), somehow unsettling this canonical divide.

Previous studies on the results of video searches on Google have not been found. Regarding the scientific topics for our present undertaking, there are only a few precedents about vaccine webpages. A study carried out in 2002 on Google concluded that 43% of the first 10 websites in search results were anti-vaccination (Davies, Chapman, & Leask, 2002). More recently, Arif et al. (2018) found that most vaccine webpages returned in Google searches in 6 different languages were pro-vaccine (43%–70%, with diverging results depending on the language).

Various forms of scientific content dissemination have been widely studied, however extant literature on promoters and drivers of this information is limited. In digital communication, the term 'user' designates a natural or legal person using a computer or network service. Growing access to information and communication technologies has facilitated the transformation of some users into producers. We focus on the different producers that create and disseminate online scientific content: professionals and amateurs, organizations and individual users. In this sense, the work of Burgess and Green (2013) on YouTube suggests that all users have become 'participants' in the same scenario, but the differences between content producers persists and varies depending on their range and motivations. Delving further into this aspect is vital, so this article provides a classification of video producers.

2.3. Scientists' Voices

Traditionally, two kinds of video content have been distinguished: user-generated content (UGC) and professionally generated content (PGC). UGC used to be amateur but widespread on social media, while PGC occurred mainly in video marketing or media communication, in other words, it was mostly employed to create institutional content (Kim, 2012). Currently, there are amateur users called 'YouTubers' who have become professionalized, while some professionally-produced content imitate amateurism (León & Bourk, 2018). A previous study indicates that UGC deals with scientific controversy more often than PGC (Erviti et al., 2018), which could be a predictor that this type of users might be more likely to produce anti-science videos.

Beyond the differentiations between UGC and PGC, it is interesting to note in what proportion some actors, such as scientific institutions, media, business, or citizens are producers of scientific videos. Besides, it might lead to improving the existing knowledge about the presence of scientific voices in online videos in relation to pro-science and anti-science attitudes.

Previously, we explained the prevalence of anti-science voices in press articles on climate change. In Petersen et al. (2019), the voices of 386 prominent contrarians (academics, scientists, politicians, and business people) gained far more visibility than the 386 highest cited climate scientists. The authors "demonstrate why climate scientists should increasingly exert their authority in scientific and public discourse, and why professional journalists and editors should adjust the disproportionate attention given to contrarians" (p. 1).

On social media, scientists should also be prominent voices, but only 2% of Twitter content and 3% of Facebook posts on climate change come from scientific work (Grouverman, Kollanyi, Howard, Barash, & Lederer, 2018). As producers of online video on this issue, scientific institutions are seemingly overcome by the media (Erviti, 2018). Meanwhile, calls are made for scientists

to become climate activists (Gardner & Wordley, 2019) and the role of academic climate advocacy is discussed (Boykoff & Oonk, 2018).

Regarding vaccines, Orr and Baram-Tsabari (2018) concluded that the virtual dialogue on the polio vaccination debate on Facebook had become more political than scientific. Finally, the few studies about the online conversation on nanotechnology conclude that the most active users appear to be individuals rather than the official channels of scientific institutions, although the retweets of news from *Nature*, *Scientific American*, NASA, etc., stand out (Veltri, 2012). Even Runge et al. (2013, p. 1) discovered that, in the US, tweets were "more likely to originate from states with a federally funded National Nanotechnology Initiative center or network."

3. Research Questions and Hypotheses

The research questions of this research are the following:

RQ1. To what extent do scientific videos obtained through the Google search engine have a neutral orientation, or are positioned in favor or against established scientific knowledge?

RQ2. Which video producers are more likely to launch neutral messages, for, or against established scientific knowledge?

RQ3. To what extent are the voices of scientists used in neutral videos, in favor, and against established scientific knowledge?

In addition, three hypotheses are formulated in relation to RQ2 and RQ3. RQ1 seeks a first approximation to the positioning of science videos, so we do not have a previous hypothesis.

H1. In our classification of producers, the positioning against established scientific knowledge is greater in videos produced by users (UGC) than in videos produced by other actors.

H2. Neutrality is more frequent in videos produced by news media than in videos produced by other actors.

H3. The presence of scientists is more frequent in videos positioned in favor of established scientific knowledge than in those against it.

H1 is based on previous research that provides conclusions to support this hypothesis (Song & Gruzd, 2017; Venkatraman et al., 2015). H2 is supported by the traditional journalistic principles of objectivity and balance (e.g., Boykoff, 2007). Finally, regarding H3, since the majority of the scientific community supports the existence of an anthropogenic climate change, the efficiency of vaccination and the benefits of nanotechnology, we assume

that those videos in favor of established scientific knowledge could portray more scientists than those videos against science.

4. Methodology

The sample of videos that we selected for this research comes from a comprehensive research project that has produced a number of results, some of which were published in a collective work (León & Bourk, 2018).

This project conducted content analysis of online videos about three topics: climate change, vaccines, and nanotechnology. The selection of these three scientific topics is related to contemporary disciplines—in Environment, Health, and Technology—receiving public and academic attention, however noticing marked differences among them as explained in the introductory section.

The sample was selected by searching for the English terms 'climate change,' 'vaccines' and 'nanotechnology' on the videos section of Google. This search engine was used because it was the most frequently tool employed by users, and it would therefore yield videos with the largest potential projection.

The search was conducted in Spain on October 16, 2015. An incognito window was opened on Google to conduct anonymous searches, all cookies were deactivated and the cache memory cleaned, factors which might have interfered with the reliability of the results. The system returned 600 webpage links for each search term, which were conditioned by the search engine algorithm. The results were filtered, excluding those videos that were not accessible due to technical problems, did not cover the subject matter as the main topic, or were repeated. Videos that exceeded 20 minutes in length were also excluded due to limited resources for their analysis, due to operational reasons (e.g., including videos over 20 minutes in the sample would have made coding analysis unfeasible). Following this filtering process, our sample resulted in 300 videos on climate change, 268 on vaccines, and 258 on nanotechnology ($n = 826$).

An initial coding proposal was discussed in three meetings of the research team, resulting in a code book that was designed to carry out the analysis. Before starting this process, a pre-test of the questionnaire was carried out, in which two coders applied the code to 5% of the sample, aimed at detecting problems of comprehension and making the necessary adjustments. Following the testing phase, the final code book was reached. Once the coding of the videos was completed, a reliability test was carried out. The test consisted in taking 10% of the coded sample and comparing whether the coding carried out by the coders matched. The agreement between the two coders that performed the task was higher than 85% for each variable used in this study.

Table 1 lists the variables and questions of the code book.

Table 1. Code book

Topic	Climate change; Vaccines; Nanotechnology.
Video title/Host webpage	(title/name of the host webpage).
Type of author	Scientific institution (research/technology center, university, etc.); Company (excluding media companies); Media (newspaper, radio, television, digital media, etc.; Non-scientific institution (NGO/Association); UGC, understood as non-institutional videos on platforms like YouTube; Other.
Does the video take a position in favor (pro-science) or against (anti-science) established scientific knowledge?	No (neutral); Yes.
In case it does, it takes a position:	Against established scientific knowledge (anti-science). E.g., against vaccination/nanotechnology or denying anthropogenic climate change; According to established scientific knowledge (pro-science).
Do scientists speak in the video?	No; Yes; Unclear whether they are scientists or not.

The data and information collected were quantitatively analyzed and the three hypotheses of the study statistically contrasted through a chi square test.

5. Results

5.1. Research Question 1

Most videos in the sample (55.4%) take a pro-science stance, while 40.4% are neutral, and only 4.1% take a stance against science. The pro-science or neutral positions are predominant in the three topics of our study. Climate change is shown as the topic in which the pro-science stance is most frequent (68.3%) and least neutral (28.3%).

Vaccines turn out to be the scientific issue that generates most controversy, with 8.2% of videos positioned against established scientific knowledge. Climate change follows those results, with 3.3% of videos against established scientific knowledge. Finally, nanotechnology is by far the least controversial (0.78% of videos

against) and often addressed from a neutral stance (49.6%; Table 2).

5.2. Research Question 2

Results indicate the predominance of online and offline media as producers of video with scientific content (52.7%). Behind the mass media, we find scientific institutions (15.7%), UGC (12.1%), non-scientific institutions (10%), companies (6%), and other producers (3.2%). We tested whether these frequencies are significantly different and they are on the whole (X^2 (5) = 113.41; $p < 0.001$), but not compared with scientific institutions and UGC (X^2 (1) = 1.96; $p > 0.05$), or UGC and non-scientific institutions (X^2 = 1.58; $p > 0.05$).

Surprisingly, non-scientific institutions are the producer that stands out in favor of established scientific knowledge (71%), even ahead of scientific institutions (65.3%; Table 3). Examples of non-scientific institutions are the World Wildlife Fund (*The Arctic: Our First Sign of Climate Change | Ocean Today*), the TED

Table 2. Positioning of videos.

	Pro-science	Anti-science	Neutral
Climate change (%, n = 300)	68.3	3.3	28.3
Vaccines (%, n = 268)	46.6	8.2	45.1
Nanotechnology (%, n = 258)	49.6	0.7	49.6
Total (%, n = 826)	55.4	4.1	40.4

Table 3. Video producers.

	Pro-science	Neutral	Anti-science
Media (%, n = 436)	54.3	42.2	3.4
Scientific institution (%, n = 130)	65.3	33	1.5
Non-scientific institution (%, n = 83)	71	25.3	3.6
User (UGC; %, n = 100)	46	41	13
Company (%, n = 50)	44	56	0
Other/unknown (%, n = 27)	33.3	62.9	3.7
Total (%, n = 826)	55.4%	40.4%	4.1%

H1: X^2 (1) = 22.75; p < 0.001
H2: X^2 (1) = 1.19; p > 0.05

Foundation (*The Reality of Climate Change | David Puttnam*, TEDxDublin, 2014) and the UN (Our *Future | Narrated by Morgan Freeman*, 2014).

Media take a pro-science stance much more frequently than a neutral stance, which situates communication companies in an intermediate position (54.3%). Meanwhile, less than 50% of videos produced by users (46%), companies (44%) and other producers (33.3%) are in favor of established scientific knowledge. In the last two cases, producers tend to offer neutral videos: companies, 56% of videos; other producers, 62.96%. If we disregard the media, the weighted percentage of neutral videos is 32%.

The most outstanding percentage of videos positioned against established scientific knowledge is the one corresponding to users (13%). This is relevant because it clearly exceeds the categories of other producers (3.7%), non-scientific institutions (3.6%) and media (3.4%). If we disregard UGC, the weighted percentage of anti-science videos is 2.8%.

On the other hand, scientific institutions hardly offer videos that contradict science (1.5%). Companies in the sample did not produce videos against established scientific knowledge but mostly neutral videos (apart from the 'others' category).

Next, we checked whether hypotheses 1 and 2 are fulfilled. The contrast of hypotheses through the chi square test confirms H1 (X^2 (1) = 22.75; p < 0.001; the parameters 'users' and 'videos against' are interdependent). Therefore, it is confirmed that, in the videos produced by users, the percentage against established scientific knowledge is higher than the percentage against science in the videos by the rest of producers.

Our second hypothesis (H2) was that, among the videos produced by media, the percentage of neutral videos would be higher than among the videos by other producers. However, this hypothesis is not confirmed by the chi square test (X^2 (1) = 1.19; p > 0.05). Therefore, it cannot be stated that the media take a more neutral stance than the rest of producers.

Among 34 videos that took an anti-science stance, 18 (52.9%) were linked to YouTube and one of them to Facebook. The remaining 15 were linked to several online news media—either legacy media like *The Guardian*

or *ABC News*, or newcomers like *The Huffington Post*. Although these media are not detractors of science, in some cases they produced videos giving exclusive voice to those who denied established science (e.g., "US climate change deniers," 2015) and provided links to videos of other anti-science producers (e.g., "Sarah Palin compares climate change 'hysteria' to eugenics," Relly, 2014).

Who are, then, the dissonant voices in our sample? In climate change videos, we find several American conservative politicians, like Sarah Palin, Ben Carson and Carly Fiorina, as well as the Prime Minister of India, ultranationalist Narendra Modi. The list also includes several controversial people, like the author of *The Skeptical Environmentalist* (2001), Bjorn Lomborg, and the nuclear industry consultant and former president of Greenpeace Canada, Patrick Moore. The denialist think tank Heartland Institute is also included in the sample.

As far as vaccine videos are concerned, dissonant voices came from candidates for the Republican nomination to the Presidency of the US, Donald Trump and Rand Paul; YouTube channels (Experimental Vaccines; Hear this well; Autism media channel); Facebook celebrity Dr. Tenpenny on vaccines and current events; Irish broadcaster and politician Paschal Mooney; and radio show host and conspiracy theorist Alex Jones.

Only two videos take an anti-nanotechnology stance and no relevant voices from public opinion are included.

5.3. Research Question 3

Voices of scientists are more frequently represented in videos about vaccines (53%), followed by videos on nanotechnology (46.5%) and climate change (27%). As seen in Table 4, scientists are more likely to be present in pro-science videos (46.5%) than anti-science clips (35.3%) or neutral ones (35.3%). Similarly, videos without scientists make up 53.5% of pro-science videos, compared with 64.7% of anti-science and neutral ones. However, the differences are not statistically significant (X^2 (1) = 1.60; p > 0.05). Therefore, H3 is not supported: scientists have no statistically significantly stronger presence in videos favoring established scientific knowledge than in videos against or neutral about such knowledge.

Table 4. Scientists' voices.

	Pro-science (%, n = 458)	Anti-science (%, n = 34)	Neutral (%, n = 334)
Videos with scientists	46.5	35.3	35.3
Videos without scientists	53.5	64.7	64.7
H3: X^2 (1) = 1.60; p > 0.05			

6. Discussion

We have asked to what extent scientific videos obtained through the Google search engine have a neutral orientation, or are positioned in favor or against established scientific knowledge. Our results show that the videos obtained through the Google search engine are mainly positioned in favor of established scientific knowledge or display a neutral stance. Only a few videos were found to question the established scientific knowledge on climate change, vaccines, and nanotechnology. This result does not necessarily mean that this is also the case for the whole Internet universe, since it is known that the algorithms that the Google search engine uses to numerically assign the relevance of the documents that are indexed (called PageRank) give priority to videos from relevant sources, thus potentially minimizing the presence of videos from sources that take an anti-science stance.

Our results contradict those of other studies that found a more prominent representation of videos with an anti-science stance on YouTube, as explained in the introductory section (Allgaier, 2019; Avaaz, 2020; Ekram et al., 2019; Song & Gruzd, 2017; Venkatraman et al., 2015; Yiannakoulias et al., 2019). The differences in search results on Google and YouTube have been empirically verified in the present study. This indicates that Google is a safer search engine when it comes to finding reliable information, while YouTube video recommendations remain controversial.

We asked which video producers are more likely to launch neutral messages, for, or against established scientific knowledge. The videos produced by non-scientific institutions are more frequently in favor of pro-science than those produced by other types of producers, including scientific institutions. This may be explained by considering that among non-scientific institutions there are national and international institutions, as well as NGOs that support science. Researchers have discussed the role of NGOs in science communication (e.g., Doyle, 2007, on climate change; Vanderslott, 2019, on vaccines). Here empirical evidence of its weight in pro-science videos is provided.

Some videos with an anti-science stance have been produced by news media, as part of their information about opinions of outsiders (groups or individuals). In such cases, it cannot be stated that the media play against established scientific knowledge, since they fulfill the informative mission of offering a varied set of opinions on a given topic, trying to strike a balance among several sources.

In addition, the context in which the aforementioned videos were published should be taken into account. Even though we only analyzed the video content, in many cases videos are part of a news site where each video is contextualized with accompanying text. Moreover, some other videos had previously been broadcast on television, where a presenter introduces the video providing some contextual information.

In general, results indicate that the media are pro-science. It cannot be stated that they take a more neutral stance than the rest of video producers (H2) and the number of anti-science videos produced by media is low. However, research on climate change conducted by Petersen et al. (2019) found that, even in prestigious news media like *The New York Times*, *The Guardian* and *The Wall Street Journal*, 'climate skeptics' were cited slightly more often than voices supporting scientific consensus. This raises the question whether points of view against scientific consensus are used too often, perhaps because they are regarded by journalists as being more interesting for the public.

Only one of the three hypotheses that we posed has been corroborated: In the videos produced by users (UGC), the positioning against science is greater than in the videos produced by other actors (H1). Most UGC videos were distributed via YouTube, which confirms previous research linking this platform and anti-science videos (Allgaier, 2019; Song & Gruzd, 2017; Venkatraman et al., 2015).

Quite surprisingly, H3 has not been demonstrated. Contrary to what we hypothesized, scientists are evenly represented both in videos with a pro-science stance and in videos with an anti-science stance. The reason might be that the sample of anti-science videos was small. In any case, it is likely that detractors include scientists in their videos to provide an image of epistemological authority.

7. Conclusions and Limitations

Our research has provided the first empirical evidence showing that the characteristics of videos obtained through the Google search engine may differ significantly from those of YouTube. In particular, we have demonstrated that, compared to YouTube videos, the videos obtained through the Google search engine display a differ-

ent position regarding the support of established scientific knowledge.

Furthermore, among the videos obtained through the Google search engine, an anti-science stance is more frequent in UGC than in other types of content. Our research has also demonstrated that non-scientific institutions play a notable role in the diffusion of reliable scientific information, since the videos they produce often support established scientific knowledge.

The relatively small representation of videos with an anti-science stance in the results provided by Google videos can be regarded as positive. After all, this search engine provides results that usually support established science, thus minimizing the possible impact of misinformation that results from spreading information that contradicts established scientific knowledge.

We have also confirmed that the neutral stance is no more frequent in videos produced by news media when compared to other producers. In general, the media tend to support established scientific knowledge, though still lending space to the representation of anti-science videos. Even if this result is consistent with the journalistic principle of balance, it can have a worrying potential contribution to the public's misinformation about certain scientific disciplines.

Since science detractors frequently give voice to scientists in videos that contradict established scientific knowledge, it is advisable for science advocates to counter that trend and reinforce the presentation of scientists' voices in their productions as well. It is also recommended that scientists who support established scientific knowledge should play a more active role in spreading science through online video, which has become a most relevant source of scientific information for the public.

The results of our research are admittedly limited to a specific search through Google videos. However, we consider that it is possible to generalize some relevant conclusions, based also on the contrast of our results with previous studies. It provides a starting point for future research on science communication through online videos.

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Conflict of Interests

The authors declare no conflict of interests.

Supplementary Material

Supplementary material for this article is available online in the format provided by the author (unedited).

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