



French Science Communication on YouTube: A Survey of Individual and Institutional Communicators and Their Channel Characteristics

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Science videos on YouTube attract millions of viewers each month, but little is known about who the content producers are, how they work and what their motivations and qualifications are. Here, we analyze the characteristics of 622 French YouTube science channels and 70,795 science videos in French, and complement this analysis with a survey of 180 of these youtubers. We focus on three questions: who are the science communicators (sociodemographics, resources, and goals), what are the characteristics of their channels, and are there differences between institutional and non-institutional communicators. We show that French science communicators on YouTube are mostly young men, highly qualified and usually talking about their topic of expertise. Many of them do not earn enough money to make a living out of this activity and have to use personal money to run their channels. At the same time, many are not interested in making this activity their main source of income. Their main goal is to share science and stimulate curiosity, as opposed to teach and entertain. While a small number of channels account for most of the views and subscribers, together they are able to cover a lot of scientific disciplines, with individuals usually focusing on a couple of fields and institutions talking about more diverse subjects. Institutions seem to have less success on YouTube than individuals, a result visible both in the number of subscribers and engagement received in videos (likes and comments). We discuss the potential factors behind this discrepancy, such as the lack of personality of institutional channels, the high number of topics they cover or the fact that institutions usually have an additional goal compared to individuals: to present and promote the institution itself. A video version of this article has been recorded and made available here: <https://stephanedeboue.net/youtube>

Keywords: science, youtube, communication, institution, popularization

INTRODUCTION: YOUTUBE AND SCIENCE COMMUNICATION RESEARCH

YouTube is the second biggest website behind the Google search engine according to the Alexa ranking (Alexa.com, 2020). But YouTube is much more than a “website”: it is a main driver of participatory culture allowing diverse types of communicators to produce diverse types of video content for diverse types of users (Burgess and Green, 2018); it is a “key element” in digital culture

(Kavoori, 2011, p. 3); and it is one of the most relevant communication channels (Snickars and Vonderau, 2009).

It comes as no surprise that the fields of science and environmental communication have realized the relevance of YouTube (Allgaier, 2019). The topic of science has long been a considerable part of YouTube's content (Yang and Qian, 2011; León and Bourk, 2018a), and thousands of science-related videos are available in the present day (Allgaier, 2020). Accordingly, Erviti and León (2016) conclude that "Science & Technology" is a popular topic on YouTube. The video platform is also one of the public's most important sources for scientific content, as shown in surveys for countries like France, Germany, and Switzerland (Lecture Jeunesse, 2020; Schäfer et al., 2018; Wissenschaft im Dialog, 2018). YouTube's relevance is even higher among younger people and, therefore, likely to increase over time (Hargittai et al., 2018; Metag et al., 2018).

Nonetheless, science communication research on YouTube is still in its infancy (León and Bourk, 2018b; Allgaier, 2020). A few studies have looked at users' information seeking behavior (Rosenthal, 2018) and at the effects of science-related YouTube content on users (Reif et al., 2020). Most studies analyze video content on controversial, socioscientific issues, such as climate change (Shapiro and Park, 2015; Allgaier, 2019), fracking (Jaspal et al., 2014), and health (Keelan et al., 2007; Yang and Qian, 2011; Harris et al., 2014). They also analyze information accuracy, formal aspects including video-editing (Muñoz Morcillo et al., 2016), content characteristics (Muñoz Morcillo et al., 2019), and factors that predict video success (Welbourne and Grant, 2016; Velho et al., 2020). Almost all of these studies look at content in English and therefore miss out on different cultures and regions (Allgaier, 2020).

When it comes to the content communicators, i.e., the science communicators themselves and their resources, intentions and motivations, then large quantitative studies are lacking (Muñoz Morcillo et al., 2019; Allgaier, 2020). As Muñoz Morcillo et al. (2019, p.3) put it, research on the YouTube production context "focuses on a scientific topic, on a small amount of data, or is limited to a qualitative level, where results cannot be generalized". Qualitative studies have indicated that there are differences between various types of communicators. Welbourne and Grant (2016) compared science-related YouTube videos between media corporations and amateur content producers. They were able to show that amateurs posted fewer videos but had more subscribers and video views, indicating that the presumed gap in resources did not hinder amateurs' success. Somewhat contradicting this finding is another study by Erviti and Stengler (2016) who interviewed five "major content providers" behind the most successful science channels in the United Kingdom and concluded that individual YouTubers might not be able to compete with professional institutions such as the BBC. Furthermore, a study not only showed that there were fewer female communicators on popular science-related channels, but that they were exposed to more hostile and sexist user comments (Amarasekara and Grant, 2019).

Another finding is the simple but important acknowledgment that different communicators follow different goals when using YouTube. Goals such as archiving and documenting (academic)

work have been observed as a common usage of YouTube for certain scientists (Bischof and Both, 2015), which starkly differs from goals like science outreach and user engagement (M. C. Erviti and Stengler, 2016). When looking at institutional science communicators, it seems that universities' content has primarily been analyzed because they are known to use YouTube to promote themselves mainly (Pham et al., 2017; Mwenda et al., 2019).

Recently, two studies started filling the quantitative research gap on content communicators on YouTube. Muñoz Morcillo et al. (2019) relied on video content and complemented it with publicly available channel information to analyze the science video producers' gender, age and professionalism. Their sample consisted of the 190 most popular channels in multiple languages across 76 countries in YouTube's "Science and Education" category. They found that three quarters of producers were male, many of them between 26 and 35 years of age and that only 14% of channels managed to post more than one video per week while still adhering to high quality standards in terms of resolution and sound quality. While this study somewhat started to overcome the limitation of focusing only on content in English and analyzed content communicators on a larger scale, it was limited to popular channels, did not differentiate between channel languages, and still had to infer all of its insights from video content and channel information.

Velho et al. (2020) on the contrary provided direct insights about 26 science communicators of a Brazilian alliance of YouTube channels. Similar to Muñoz Morcillo et al. (2019), they showed that most communicators were highly educated men aged 18 to 35 with expertise in the natural sciences. These communicators indicated that they were struggling with not having enough resources to frequently produce content, not being able to live off YouTube generated income, and trying to optimize their production process in light of the opaque YouTube recommendation algorithm. As a result, many of them have to rely on crowdfunding to keep their channels alive. Although this study focused on a smaller sample, it was able to provide some first quantitative and direct insights into science content communicators on YouTube beyond the english-speaking world.

This lack of large-scale direct insights on science communicators on YouTube should be remedied for at least two reasons. First, there are numerous types of successful science communicators on YouTube. On French-speaking YouTube alone, large subscriber bases were built by very different actors: scientists like "Science étonnante" (ca. 950,000 subscribers), science enthusiasts like "Dr. Nozman" (3,600,000), science journalists like "Science de comptoir" (21,000), and scientific institutions like "Inserm" (160,000). Second, YouTubers are part of the current reconfiguration of the science communication ecosystem. A pluralization of science communicators including not only established science journalists but also individuals like bloggers and citizen journalists as well as institutional communicators has been taking place online (Schäfer, 2017b). Yet, there is still a lot more research available on science journalists, the "traditional" intermediaries between science and society. Studies have analyzed science

journalists' sociodemographics, their vocational skills, motivations and resources (Berg, 2018; Dunwoody, 2019). Large studies in Germany and Switzerland, as well as a smaller one in France, show that science journalists are usually highly educated and want to inform and explain rather than to be a watchdog (Marcotte and Sauvageau, 2006; Kristiansen et al., 2016; Berg, 2018). Research also shows that science journalism is in a "crisis" of shrinking resources because fewer and fewer media houses invest in specialized science journalism (Schäfer, 2017b). This raises the question of whether such diagnoses regarding the "traditional" intermediaries translate to the science communicators on YouTube.

When it comes to institutions in particular, a prevailing notion is that they are not overly interested in communicating on social media in general (Schäfer, 2017a). However, the presence of institutional science communicators has not only been studied by recent analyses of YouTube, it has also been observed more generally in science communication online: communication departments of large scientific institutions have more and more resources available and they use them to communicate on various channels (Hauser, 2020). Public relations texts are a successful way of getting into these news media and their content often directly competes with editorial content by science journalists (Vogler and Schäfer, 2020). This finding also seems to apply to YouTube, where a study found that videos posted by universities mostly aim at portraying the institution in a good light (Chen and Burns Gilchrist, 2013). The only study we know of that quantitatively compared between individuals and institutions on YouTube is the one previously mentioned by Muñoz Morcillo et al. (2019). The authors defined organizations as producers that consist of two or more people and found that almost three quarters of the 190 channels in their sample belonged to such organizations. After they had tentatively classified 46 of these organizations as "non-profit", they were able to report that almost half of them were universities.

To summarize, quantitative studies looking at science communicators on YouTube are scarce, they often rely on indirect evidence through channel and content analyses, and they often use samples restricted to the most popular channels. The present study tries to address these problems by working with a representative sample of 622 French science communicators on YouTube, analyzing them directly through an online survey and providing additional insights on their channels' characteristics (number of subscribers, number of views, creation date, publication frequency, topics addressed, video format, audience demographics and audience engagement, hereinafter referred to simply as "characteristics"), while looking at the differences between individuals and institutions, a perspective commonly encountered in the closely related literature on science journalism.

Hence, our article will be structured around three research questions:

RQ1: Who are the science communicators on YouTube? What are their sociodemographics, resources, and goals?

RQ2: What are the characteristics of the science communicators' YouTube channels?

RQ3: What are the main differences between individual and institutional science communicators on YouTube?

METHODS

Sample Construction

Generating a complete list of science channels represents a challenge for two reasons: it is a well-known problem in philosophy of science that there is no agreed-upon definition of science (Andersen and Hepburn, 2016), and there is no comprehensive resource listing YouTube channels (Allgaier, 2016). We constructed our sample in three phases: *first*, we openly gathered the largest possible list of "educational", "cultural" or "scientific" channels without any definitional restrictions; *second*, we generated a list of disciplines we considered as "scientific" in the context of this analysis; *third*, three of the four authors independently classified each of these channels as "scientific" or not, depending on this list of "scientific" disciplines.

The first step was to gather a comprehensive list of French YouTube channels that are loosely connected to science communication. Previous studies have used both narrow and broad definitions of "science communicators", focusing on professionals only (e.g., Casini and Neresini, 2013) or including scientists also (e.g., Baram-Tsabari and Lewenstein, 2017). When it comes to Youtube, websites providing analytics such as SocialBlade have been used in the past (Welbourne and Grant, 2016), but these websites are mostly referencing high-popularity channels, hence overlooking smaller channels and providing an incomplete representation of the YouTube landscape. We use a broad understanding of "science communicators" by defining them as actors that publicly communicate about "scientific" topics. This means that different actors like scientists, science journalists, professional science communicators and individuals of other backgrounds were considered "science communicators" as long as they spoke about scientific topics on YouTube (what we considered "scientific" is addressed below).

We decided to focus on French channels as it is easier to build a comprehensive list in this language due to the more limited numbers compared to English-speaking channels. We gathered channels from a wide array of sources (online, social, institutional, and personal) for our sample to be as representative as possible of the French landscape. First, we included five online directories of French YouTube channels related to science communication in September 2018 (Café des sciences, 2018; La Vidéothèque d'Alexandrie, 2018; Les Internettes, 2018; Mediapason, 2018; Yex.tv, 2018). Membership to some of these directories is self-administered, thus limiting the skew toward popular channels. For "Les internettes", we kept only channels that they categorized as Literature, Culture, Art, Science, History, Cinema, Law, Politics, Society. For Yex.Tv, we kept only channels found in the categories Education, Science, or Culture. Second, we broadly communicated and advertised our goal of constructing and accumulating such a list on various social networks to allow

small channel communicators to add themselves to this list. Adding this effort resulted in a list of 2,540 channels. Third, we ensured that the list was complete in terms of institutional channels, a key aspect to answer our third research question. We defined institutions as established science-related organizations (e.g., universities, research institutions, science outreach organisations), public or private, that exist independently of the existence of any associated YouTube channel. Neither the number of people employed by the institution nor the number of people running the YouTube channel are considered in this definition. For instance, large groups of content creators that were created for the sole purpose of making videos were not considered as institutions. Conversely, a single individual running an institution's YouTube channel is still considered an institution. In practice, we compiled our list by combining three directories of French scientific institutions: research institutes provided by the French government (Ministère de l'Enseignement supérieur, de la Recherche, et de l'Innovation, 2020), science outreach organizations that were members of a French network for the dissemination of scientific, technical and industrial culture (AMCSTI, 2020), and French universities and higher education schools (Wikipedia.org, 2020). Combining the three cited directories resulted in a list of 372 institutions, for which a manual YouTube search discovered 280 YouTube channels (i.e., 75% of institutions in our sample have a YouTube channel) (Supplementary Information, **Supplementary Table S1**). Finally, two of the authors of this paper are themselves French science communicators on YouTube and were able to fill any additional gaps in the list.

The second step was to operationalize our understanding of "scientific" channels. We defined any channel as scientific if its channel description covered at least one scientific discipline among a pre-established list. To establish such a list of scientific disciplines, we compiled a list of the 254 disciplines listed in the widely used Web of science database (Web of Science Core Collection Help, 2020). Related disciplines which could be clearly attributed to broader disciplines were merged (e.g., "Cell biology" and "Ornithology" were merged as "Biology"), resulting in a diverse list of 31 disciplines ranging from Anthropology through History, to Mathematics and Art (**Supplementary Table S2**). Out of these 31 disciplines, we decided to exclude four that are not part of the classical scientific path in France: Architecture, Art, Literature, and Languages. We also built a list of "educational" disciplines not usually taught at the university but often found on YouTube (last column in **Supplementary Table S2**). Out of these, we kept only skepticism, because its emphasis on the promotion of "critical thinking" and the scientific method makes it an important part of the YouTube scientific ecosystem. In the end, 28 scientific disciplines of interest for our study were thus identified (see **Supplementary Table S2**).

In a third and last step, we cleaned our list of individual channels to remove those not related to our list of accepted scientific disciplines. Based on the description and title of each individual channel, three raters (all of them co-authors) independently decided if each channel's focus could be considered as dealing with one of the disciplines from our list. Channels receiving at least 2 out of 3 positive answers were kept

to constitute our final sample of 372 non-institutional channels, regardless of their scientific intentions (science outreach, lectures, courses, etc.) or format (e.g., using talking-head or animations). Agreement was good among raters, with an ICC of 0.774. Channels with an empty description were removed. As this step certainly introduces some level of bias, we provide the full list of Youtube channels so that other definitions of "scientific" disciplines can be applied to re-run our analysis (Masselot, 2020).

After merging the institutional and individual channels, removing channels with no videos published (5) and removing duplicates (aggregation websites list both institutional and individual channels), the list ended up with 622 channels, 276 (44%) of them being institutional ones (**Supplementary Table S1**).

YouTube Channel Data

We gathered Youtube data from our list of science channels in July 2020. A *Python* script was used to collect information about each channel and each video published by each channel (70,795 videos in total). Only publicly available data was gathered. For channels, we recorded their creation date, number of subscribers, number of views (across all videos), and number of published videos. For each video, we gathered its title, description, date of publication, view count, like count, dislike count, and comment count at the time of extraction.

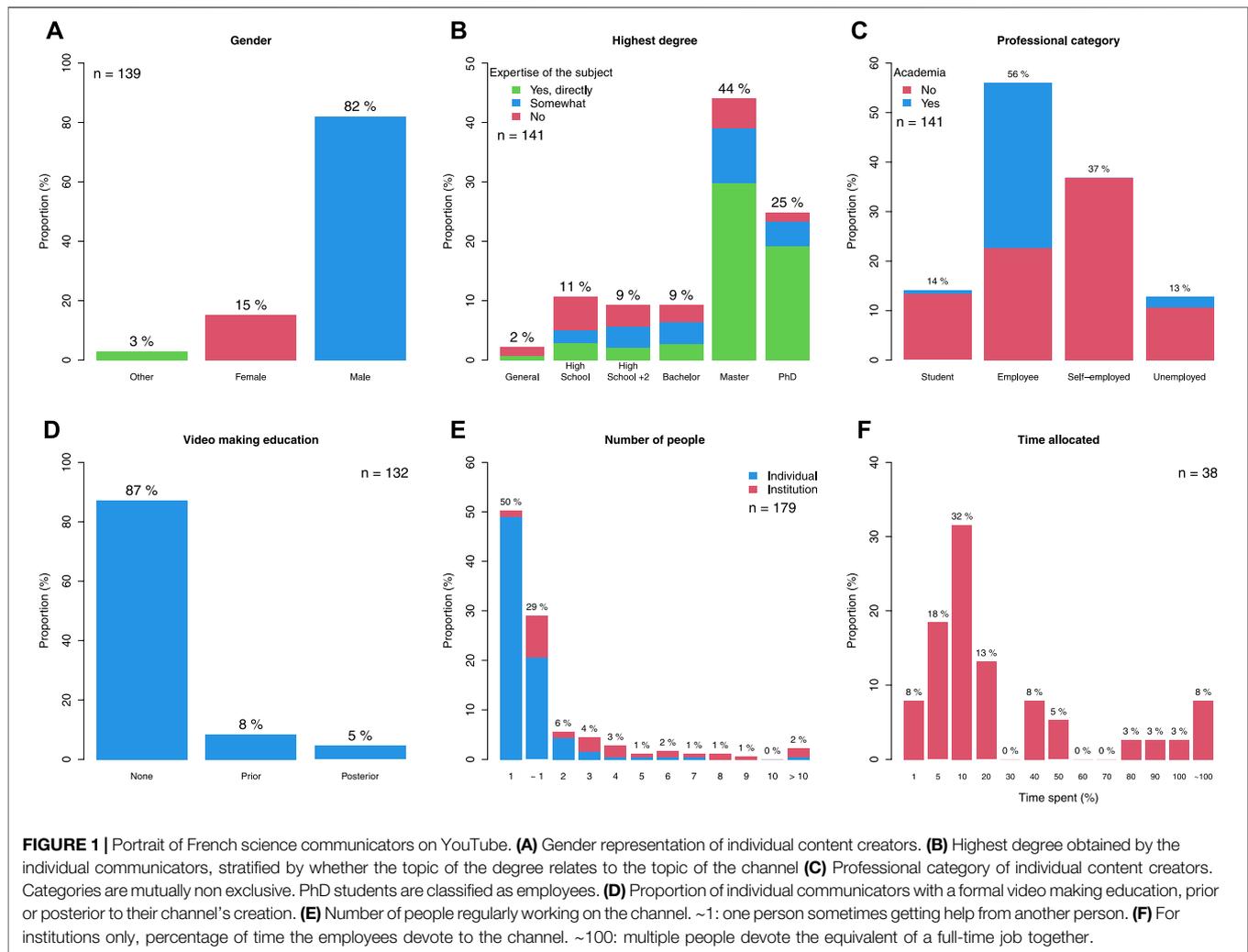
Survey of Science Communicators on YouTube

To distribute our survey, we used email addresses which were provided to us by the communicators themselves or that were found in their channel description. When we could not find any email address, we also tried to use social networks to reach the communicators. In the end, we were able to send the survey to 93% of the communicators in our sample, with a reminder one month later. 29% of the contacted channels answered our survey, with a strong difference between institutions (14%) and individuals (41%). Our final survey sample size was thus of 180 respondents (including 39 institutional channels). Most questions were non-mandatory, hence explaining the different sample sizes in the results below.

The survey was run on Google Forms, and was composed of four parts. The first part identified the respondent as an institution or an individual. The second part was dependent on the first part, and asked questions specific to institutions (how many employees are working on the channel, whether the channel is a communication priority for the institution...) or individuals (age, degree, job...). The third and fourth parts were common to all respondents and asked questions about the channel's characteristics (target audience, number of subscribers, topic...) and its financial situation, respectively. All questions asked can be found in the Supplementary Information, with an english translation.

RESULTS

RQ1: Who are the science communicators on YouTube? What are their sociodemographics, resources, and goals?



Sociodemographics

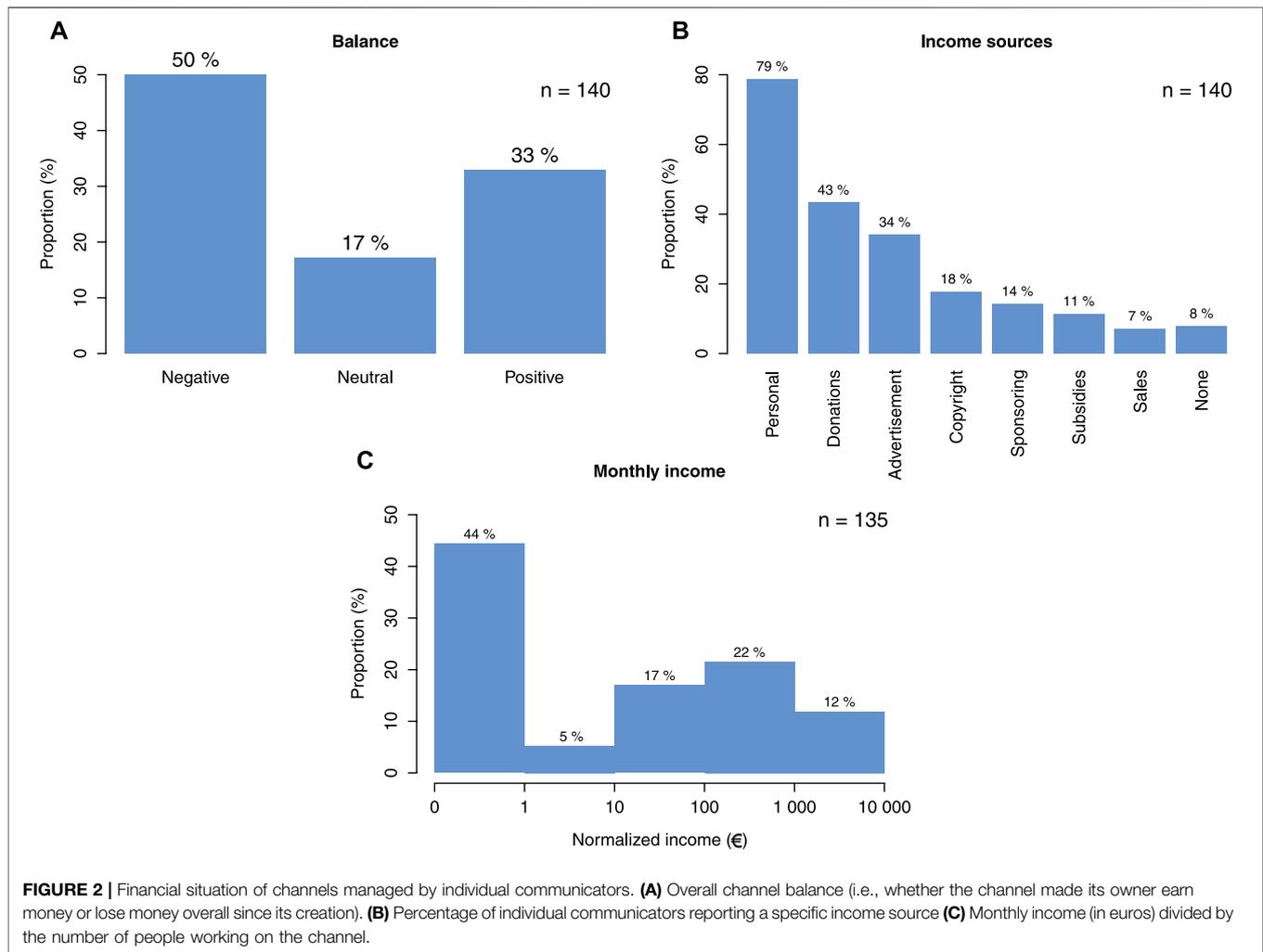
Individual communicators tend to be young adults ($M = 32.88$ years old, $SD = 10.42$, $n = 141$), predominantly male (82% male, 15% female, 3% other, **Figure 1A**), and highly educated, with 69% of them having at least a Master's degree (**Figure 1B**). They take advantage of their degrees in their science communication practice as an average of 57% of them communicate about scientific topics that are directly related to their field of expertise (**Figure 1B**). This is particularly true for communicators with a Master's and PhD degree, among which 67 and 77% respectively have direct expertise in their channel's subject.

Individual communicators are mostly employed (56%) or self-employed (37%), and 14% of them are still studying (**Figure 1C**, mutually non exclusive categories). 87% of them did not have a formal training in video making before creating their channels and classified themselves as self-taught (**Figure 1D**). This percentage drops to 54% for people managing institutional channels, while 85% of them report having been trained in scientific communication or outreach.

Resources

Half of the channels in our full sample are managed by a single person, and an additional 29% of communicators generally work alone but occasionally invite a co-worker (**Figure 1E**). 97% of people managing institutional channels do not do work on the channel as a full-time job. The specific percentage of time allocated to this activity is generally low but varies widely ($M = 19.06\%$, $SD = 21.55$, $n = 38$, **Figure 1F**). Only 3 institutions out of 38 declare "allocating a full-time job to the management of the YouTube channel, but the job is done by different employees".

Most institutional channels are funded by the corresponding institutions, sometimes helped by grants, and none of them have a positive balance through this activity (**Supplementary Figure S1**). Among individuals, most of them also have a negative (50%) or neutral (17%) financial balance, without even considering the time they spend working on the videos (**Figure 2A**). They generally use personal sources of income to cover the channel's expenses (79%) (**Figure 2B**). Donations or crowdfunding (43%) and advertisement (34%) also represent a commonly mentioned source of income. This does not mean that



doing science communication on YouTube is a profitable activity: only 12% of communicators report earning more than 1,000€ per month and per person involved, while on the other hand 44% of them report having no revenue at all (**Figure 2C**). Among individual creators who have had a positive income balance since the creation of their channel, only 22% declare having enough to make a living (non-mandatory question, $n = 56$ individuals decided to answer).

Interestingly, only 14% of content communicators who do not receive their main source of income from their channel would like this to be the case (**Supplementary Figure S2**); 29% would appreciate if it could be a secondary source of income, 19% just want to have a neutral balance, and 38% are not interested at all in earning money through their channel.

Goals

Across both institutional and individual channels, 91% of the communicators see their activity as “science popularization” (transmitting scientific content), and only 33% “teaching” (transmitting precise and detailed content). 68% also think their job is to stimulate curiosity, and only 31% to provide entertainment.

98% of communicators report that their channel’s content is (not necessarily exclusively) targeted at adults, while 66% target teenagers, and fewer target children (15%). An additional 34% also report their content being targeted at people with expertise in the content’s subject. In practice, targeting a particular age group does not seem to make a difference in the actual audience (**Supplementary Figure S3**). The audience is mostly young people (37% between 25 and 34 years of age and 30% between 18–24, **Supplementary Table S4**). Communicators report that their audience does not contain many women according to their channel’s YouTube statistics ($M = 19.26\%$, $SD = 17.36$, $n = 149$). Hence, the gender and age of the general audience are close to those of the individual video makers themselves (**Supplementary Table S4**).

54% of the institutions declare having a YouTube channel for both communicating about science and promoting the institution, 31% only for communicating about science and 5% only for promoting the institution (**Supplementary Figure S4A**). 20% of them consider publishing videos as a high or rather high priority in their communication strategy and 41% a low or rather low priority ($Mdn = 3$, $n = 39$, on a scale from 1 to 5, 1 = low

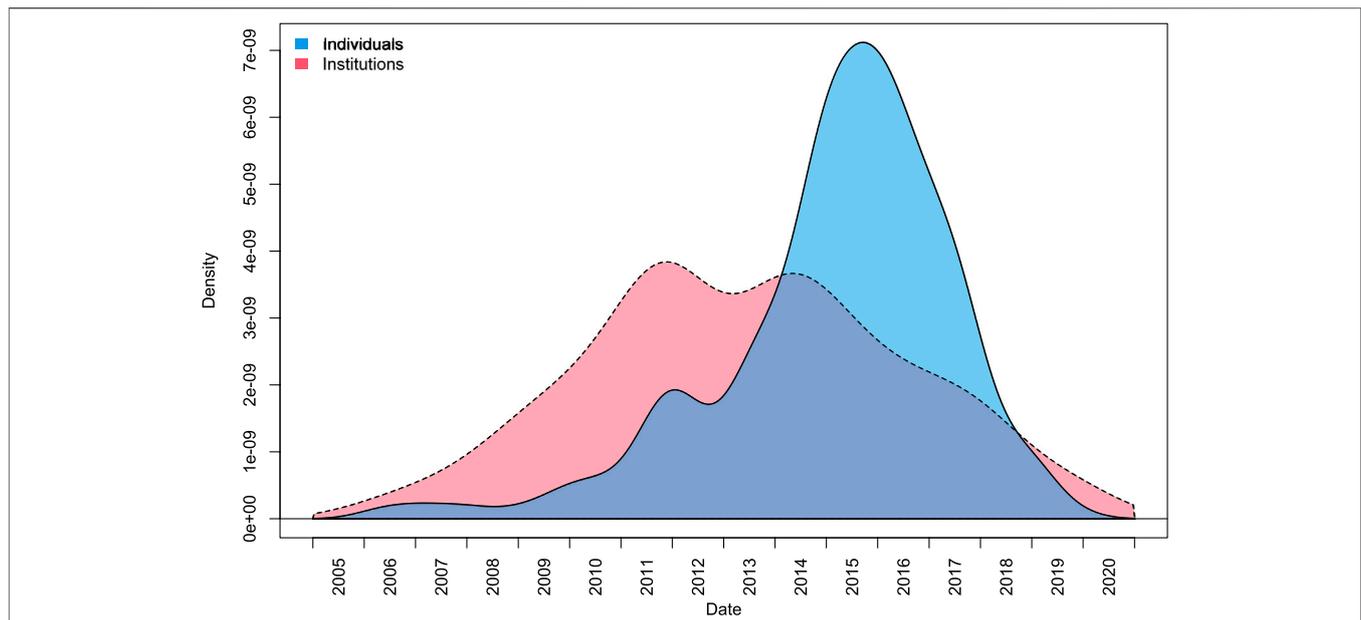


FIGURE 3 | Distribution of the date of creation of channels.

priority, 5 = high priority, **Supplementary Figure S4B**). At the same time, only 11% of them declare being rather satisfied or very satisfied with the current state of their channel (Mdn = 2, 1 = not satisfied at all, 5 = very satisfied), and 23% of them even declare being “not satisfied at all” (**Supplementary Figure S4C**). On the other hand, 51% of the institutions noticed many positive impacts or feedback linked to their channel (answer 4 or 5 to the corresponding question, **Supplementary Figure S4D**). 67% of institutions declare the creation of the channel generated no reluctance at all inside the institution (**Supplementary Figure S4E**). Furthermore, there seems to be no association between the creation date of a channel and the reluctance it generated (**Supplementary Figure S5**).

Across all communicators, only 1 out of 172 declares the YouTube ecosystem to be “very meritocratic” (i.e., that there is a good correlation between the quality of a channel and its number of subscribers, and that small channels of good quality will end up being rewarded), while 18% declare it to be “not meritocratic at all” (Mdn = 2, $n = 172$, 1 = not meritocratic at all, 5 = very meritocratic). A large number of them (39%) thinks they moderately deserve their number of subscribers (which could mean being either too big or too low, mdn = 3, $n = 175$, 1 = not at all, 5 = completely deserve), and 78% think it is important or very important that big channels give more visibility to smaller qualitative channels (Mdn = 4, $n = 179$, 1 = No, it’s not their role 5 = Yes, it’s part of their role).

The goals of the content creators in our sample are thus rather diverse. Some of them want to earn a living from this activity while others are not even looking for a neutral financial balance. Some want to reach children while others are targeting specialists of their field. Even among institutions, some use their channels to promote their structure whereas others focus on science promotion only. Despite this diversity, 90% of our sample declare being happy with their science communication activity on YouTube.

RQ2: What are the characteristics of the science communicators’ YouTube channels?

Channel Description

Most of the channels were created after 2010, with a notable difference between institutional and individual ones (**Figure 3**). The former were generally created earlier (2011–2014) than the latter (2014–2017). Institutions publish more videos per year ($M = 23.35$ videos, $SD = 23.60$) than non-institutions ($M = 13.21$ videos, $SD = 15.77$). This result is observed in both the survey and the YouTube data (**Figure 4**).

All 28 scientific fields we identified are covered by both institutional and individual channels with an important discrepancy between the two (**Figure 5**). For individuals ($n = 141$), the three most prevalent topics are History (30%), Physics (21%) and Biology (20%), whereas for institutions ($n = 39$) they are Environment (49%), Mathematics (46%) and Biology (44%). The average number of scientific fields covered by a channel is much higher for institutions ($M = 7.28$ fields, $SD = 6.98$, $n = 39$) than individuals ($M = 2.82$ fields, $SD = 2.56$, $n = 141$).

Institutions report using “talking-head as their main format” more often (59%) than individuals (39%) but they are also more prone to use animation as their main format (15% for institutional channels against 3% for individual channels, **Supplementary Figure S6**). Individuals, on the other hand, indicate that they “sometimes” use talking-head (50%) and animations (64%), showing that they might be more prone to mixing approaches.

Channel Performance

Channels managed by individuals have more subscribers than institutional ones (**Figure 6A**), with only 2% of institutional channels having above 100,000 subscribers, and none above 1

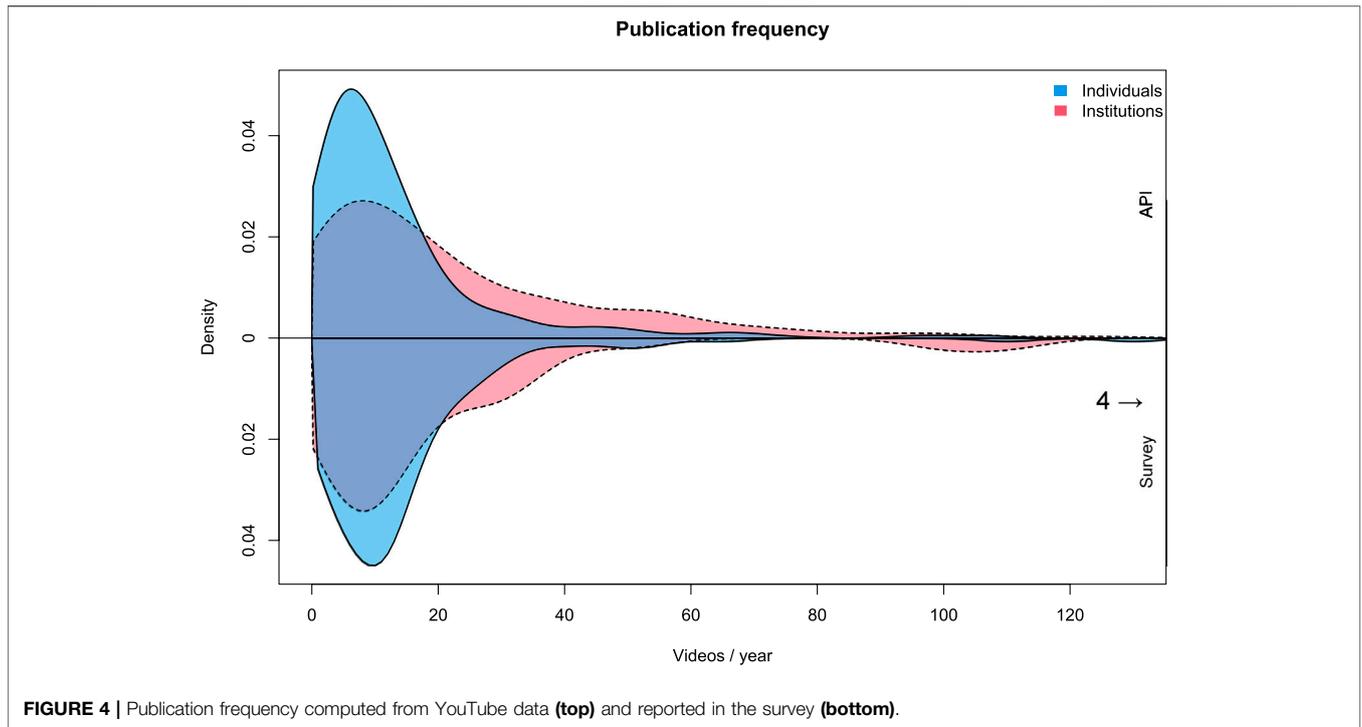


FIGURE 4 | Publication frequency computed from YouTube data (**top**) and reported in the survey (**bottom**).

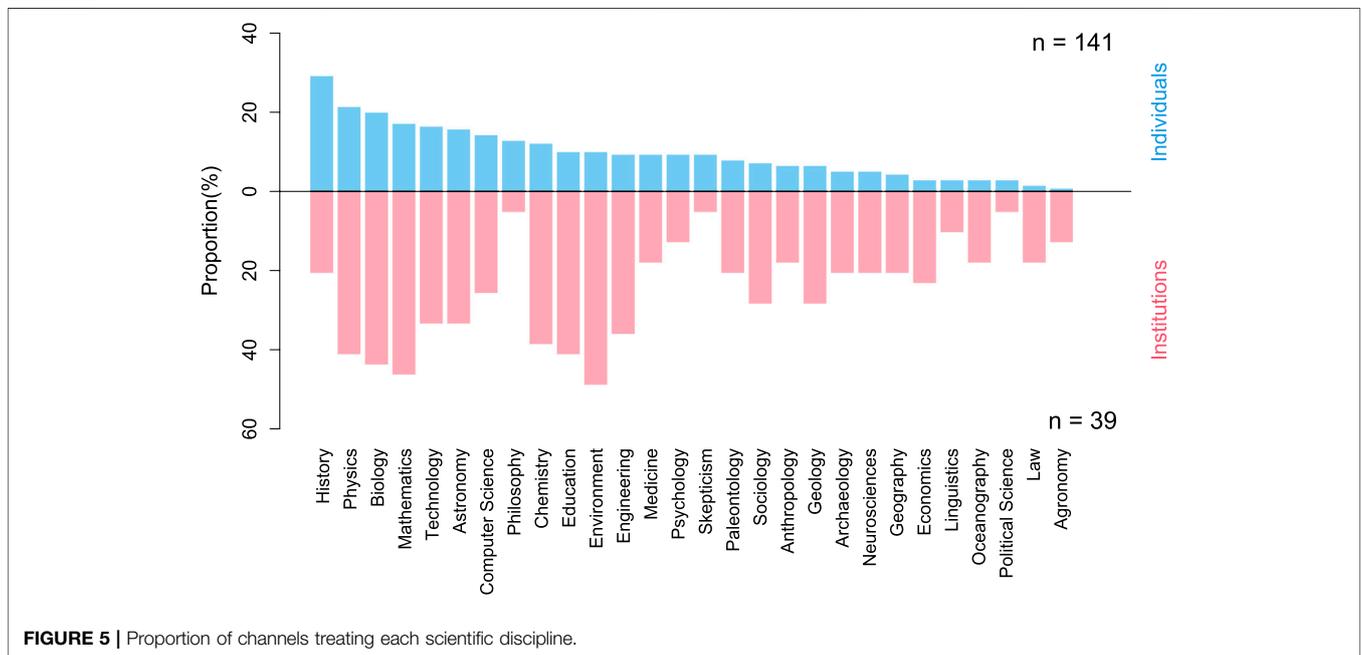
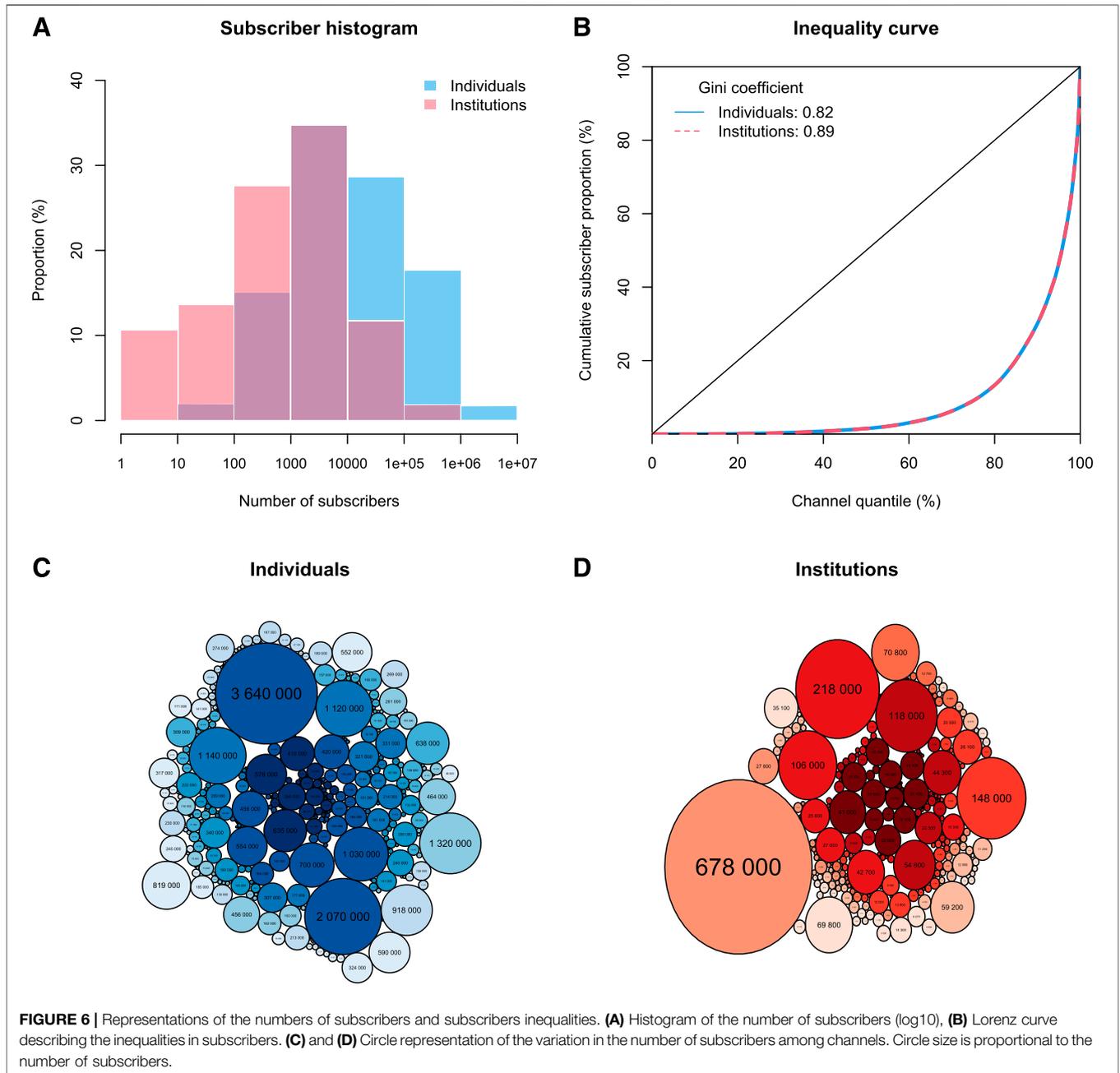


FIGURE 5 | Proportion of channels treating each scientific discipline.

million (compared to 18 and 2% respectively for individuals). Institutions also gather fewer views across all videos. Both views and subscriber variables exhibit typical heavy-tailed repartition, and logarithmic scales suggest that the lognormal distribution may reasonably describe their distribution: the majority of channels are gathered around modal values of about 1,000 subscribers and 175,000 total views (across all videos) for

institutions, and 5,000 subscribers and 130,000 views for individuals. Subscribers and views are very unequally distributed, with a small number of channels concentrating most of the views and subscribers (**Figure 6B**). Gini coefficients calculated on the number of subscribers confirm the strong inequalities among both individuals ($G = 0.82$) and institutions ($G = 0.89$). The maximum number of subscribers for

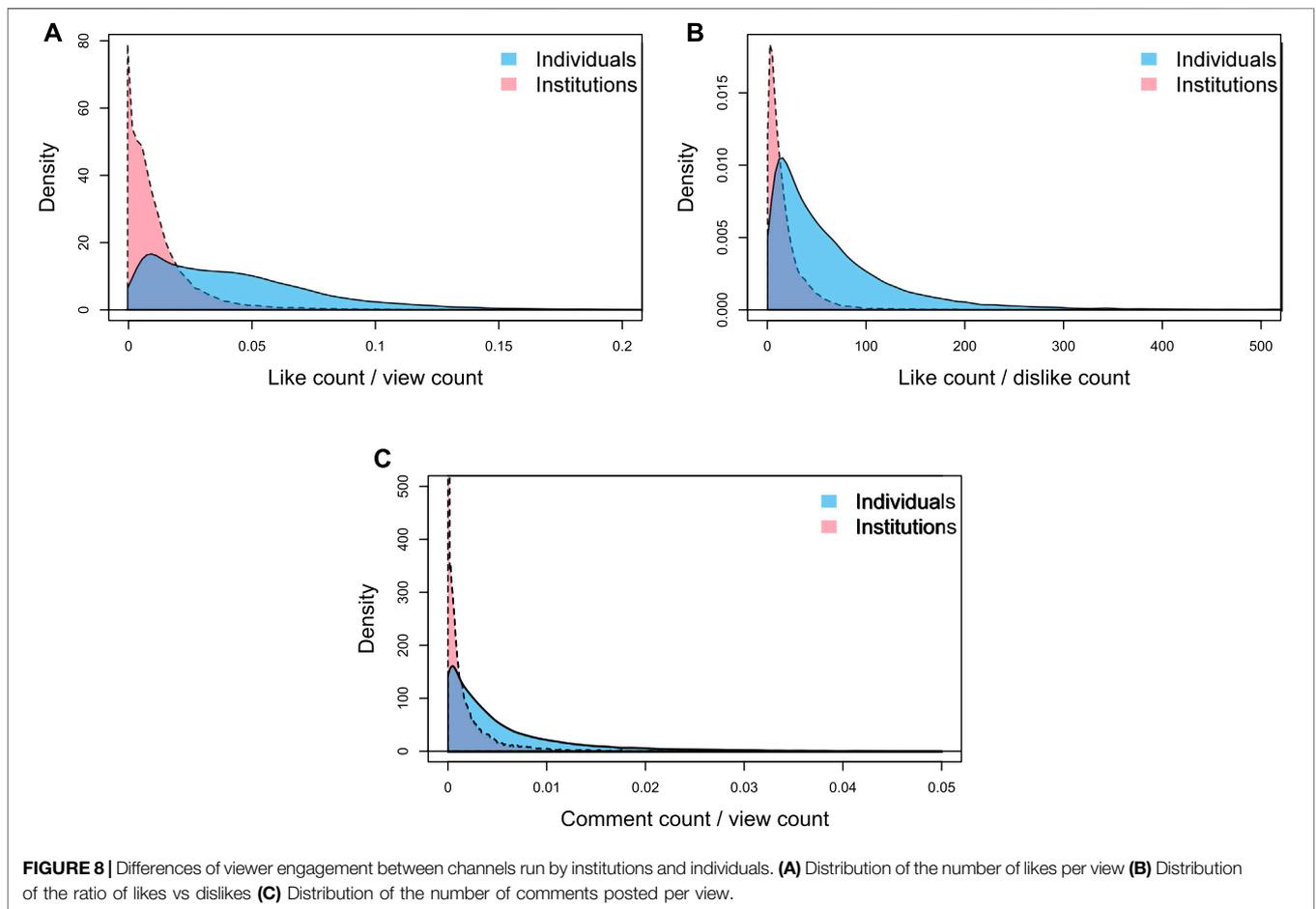
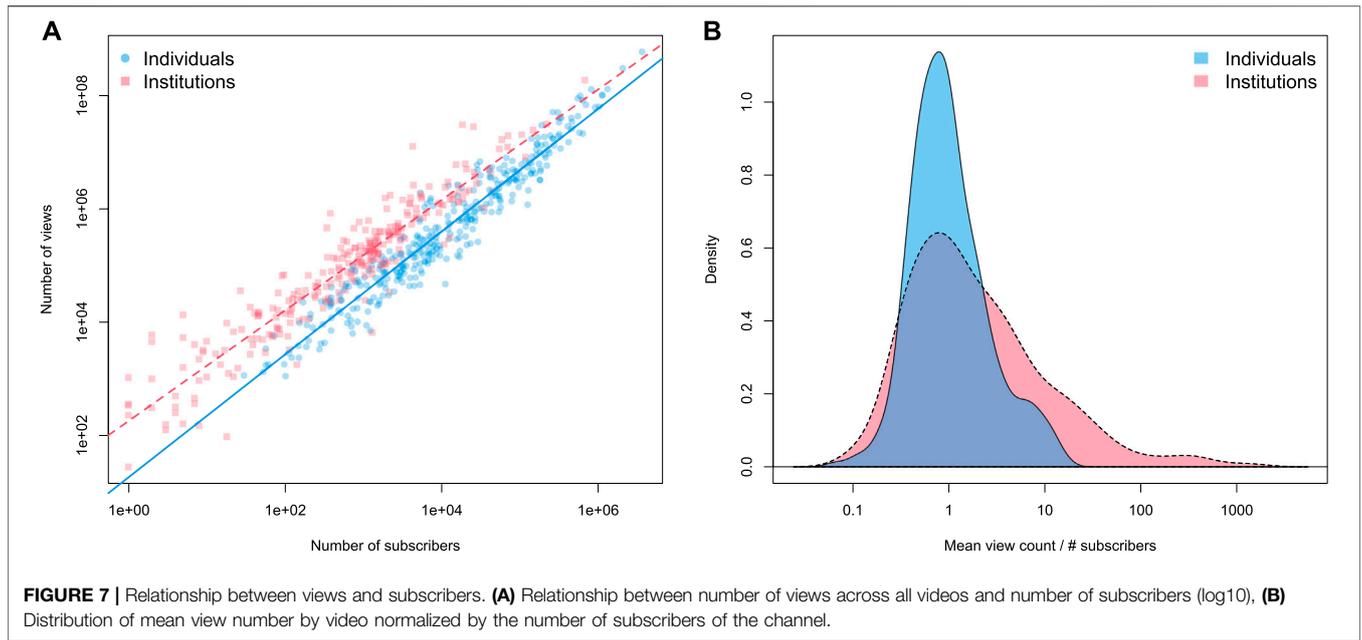


a French scientific channel as of July 2020 is 3,640,000 (Figure 6C).

For a given number of subscribers, institutions are likely to get more views than individuals (Figure 7A) but there is more variation in the number of views per subscriptions for the former (Figure 7B). The logarithmic scale on Figure 7A also shows that the more subscribers a channel has, the more views per subscribers it will have: the association between number of subscribers and number of views is linear with a slope of 1.085 for individuals and 0.975 for institutions. This correlational data implies that for individuals, multiplying the number of subscribers by 10 multiplies the number of views by

more than 10, precisely $10^{1.085} \approx 12.2$. For institutions, it will be multiplied by 9.4.

Although institutional channels have more views per subscriber, they fail to engage their audience as well as individual channels. All indicators we recorded (ratio likes/views, likes/dislikes and comments/views) are lower for institutional channels than for individual ones (Figure 8). For example, institutional videos very rarely reach a likes/views ratio above 0.05, whereas it is not uncommon to obtain such a level of engagement on individual channels (36% in our sample, Figure 8A). For individuals, the ratio likes/views slightly increases as the number of subscribers decreases, whereas the



trend is opposite for institutions (**Supplementary Figure S7**). Institutional channels also receive fewer comments per view than individual channels (**Figure 8C**).

DISCUSSION

Our results provide a number of noteworthy insights regarding the sociodemographics, resources and goals of science communicators (RQ1), the characteristics and performance of their channels (RQ2), and the differences between individual and institutional science communicators (RQ3).

One of the most pronounced findings is that individual science communicators on YouTube are mostly male, young, and highly educated. The first aspect had already been noted before (Amarasekara and Grant, 2019; Muñoz Morcillo et al., 2019; Velho et al., 2020). It is noteworthy that this young and male profile of the communicators matches that of their audiences. It is unclear if this match is due to a general homophily of audiences or because the science communicators themselves were once part of the same audience (Lecture Jeunesse, 2020). Our study is the first one to reliably show the high level of education that individual science communicators have on French YouTube. For reference, 23% of the French population has at least a bachelor's degree (Insee, 2019), compared to 78% in our survey sample (and 25% holding a PhD). This shows a similarity between science communicators on YouTube and traditional science journalists, which are known to also hold advanced degrees in France (Marcotte and Sauvageau, 2006) and neighboring countries (Kristiansen et al., 2016; Berg, 2018). Overall, science communicators on YouTube are primarily scientists, students or ex-students of scientific fields who happen to use videos as a medium to communicate, rather than audiovisual professionals who happen to talk about science. Even the people in charge of institutional YouTube channels are more trained in scientific communication or outreach than they are in video making.

By and large, individual and institutional science communicators have similar goals and treat their channels as a side-project. Results on individual communicators showed that communicating science on YouTube is a solitary hobby, as suggested by the fact that 79% of these communicators work alone most of the time and that most communicators have a main job other than making YouTube videos. Only about a third of them use their channel for teaching or entertainment purposes, while most of them focus on popularizing science and stimulating curiosity. Not only are most communicators highly qualified, but they primarily talk about scientific topics in their field of expertise, indicating a potential high quality of transmitted information. Regarding institutional communicators, most channels were set up without much resistance within the institution and are often focused on doing actual science communication, often combined with promoting the institution. Running their channel, however, is mostly a moderate priority, again indicating side-project quality.

Running a YouTube channel is rarely a profitable activity for both individual and institutional communicators. More than 50%

of individual communicators do not want to make money with their channel or just want to break even. This makes sense when considering how difficult it is to earn money from a science YouTube channel: most individual communicators report owning a channel with an overall negative income balance, with only a low number of channels earning more than 1,000€ per month. This result is highly dependent on our survey sample though: if only small channels accepted to answer our survey, they might say they do not want to earn money because they know they realistically cannot, and not because they would not like it. Nonetheless, our survey sample contains both small and large channels, and the Youtube data shows that 50% of science channels have less than 3,000 subscribers – an amount too low for any channel to be a consistent income source. The picture is very similar for institutional science communicators. Running the YouTube channel is funded through the institution's budget and the overall financial balance of their channels is mostly negative or neutral at best.

These findings are interesting when comparing the financial situation of science communicators on YouTube with the structural problems of science journalism (Schäfer, 2017b). It seems that only a few select individuals can make a living off these activities—a long-tail distribution that is also described for the digital music industry (Coelho and Mendes, 2019). This suggests that the smaller science communicators are more likely to eventually run out of personal or financial resources, being replaced by the next generation. At the same time, it seems unlikely that science journalists could use YouTube as a primary source of income. Institutional communicators are in a more comfortable position, using their institution's budget, and could presumably be more successful if they prioritized their channels more.

Overall, French-speaking science communicators on YouTube offer a high variety of topics, covering all scientific fields we identified during our sample construction, even if some fields such as agronomy, law, or political science, appear less frequently. The proportion of institutional and individual channels covering a given field can vary considerably. For institutions, the importance of fields in the natural sciences like environment, mathematics, biology, and physics, may reflect their research and teaching activities. For individual communicators, we observed a more balanced mix between natural sciences and other fields like history and philosophy.

The audiovisual quality of science communication videos on YouTube has been assessed and called into question by previous studies (Muñoz Morcillo et al., 2016; Muñoz Morcillo et al., 2019). Our results can indirectly but positively speak to the quality aspect: although almost no communicator had a formal training in audiovisual production, they report having learned a lot by themselves. Particularly, individual communicators tend to mix different filming techniques such as talking-head and animations. As already mentioned, the fact that they usually speak of a topic in which they hold a university degree certainly also suggests a high level of content quality. Future studies could nevertheless try to investigate this question of the audiovisual quality in a more focused effort.

Channels owned by individuals have more subscribers than channels owned by institutions. Our data show that very few

institutional channels reach 100,000 subscribers and none reaches 1 million. This cannot be attributed to the channels' age since institutional channels were generally created earlier than individual channels and uploaded their first videos shortly after their creation. Other indicators tell the same story: institutions and individuals sharply differ on the engagement they receive from their viewers, with individuals getting more likes and more comments per view. This could be explained by several factors. First, institutions do not only use their channel to promote science, but also to promote the institution. This factor is likely to make a strong difference as promotional videos are not likely to receive many likes and comments. Other studies could try to focus on institutional channels publishing only scientific outreach content, but this will drastically reduce the sample (dividing it by 3 according to our survey). Second, institutions declared covering more topics than individuals. This is again likely to lower the engagement as subscribers might not be interested in all the videos published. This aspect can also explain the lower number of subscribers of institutional channels, the broader editorial policy preventing the retention of a constant audience. Third, institutions publish more videos per year than individuals. Publishing regular content is often considered important to obtain visibility on Youtube, but it also comes at a cost for the quality of each video, especially for science videos which require a long phase of content research and verification. If this trade-off quantity/quality is real, publishing more videos might not be the best strategy to maintain the interest of the viewers. Finally, it might be the case that people subscribe and comment more on individual communicators' channels because they can actually identify with a presenter who continuously appears in the channel's videos. This aspect might be lacking or the presenter might be changing often for institutional channels. This type of identification and embodiment has been shown to be key in getting communication messages across on YouTube (Kaul et al., 2020), and a lack of identification could be a handicap to build a communication strategy on other social networks, slowing down the promotion of institutional channels by other content creators.

However, institutions receive more views per subscriber than individuals. It means that they are able to reach more people but fail to retain their viewers through a subscription, probably for the reasons mentioned above. But it shows that there is room for improvement regarding the success of institutional science channels on YouTube. In fact, our limited data suggest that institutions considering the publication of videos as a priority can have a higher number of subscribers (**Supplementary Figure 8**). As discussed before, many institutions do not consider their YouTube channels as a priority, but at the same time are not satisfied with the impact they have. This discrepancy may also reflect a gap between the investment into the channel at the level of the institution and the opinion of the person in charge of the channel who answered our survey.

Another important result of our study is that views and subscribers are very unequally distributed among channels, with a small number of channels accounting for most of the views, as made salient in **Figure 6**. Nonetheless, it would be a

mistake to infer that only the most popular channels are of good quality, or provide enough satisfaction to their viewers. An alternative indicator of performance is the ratio between likes and views, which could be a good proxy of how satisfied viewers are with a video, and a channel as a whole. **Supplementary Figure 7** shows indeed that this ratio is higher for small individual channels than for bigger ones. Hence, if small channels are not particularly popular, it might be for reasons other than not pleasing their viewership. However, this indicator could also be biased toward small channels, because small channels may attract a more active and motivated viewership.

In any case, many communicators are well aware that their success (or lack thereof) is in part out of their control, and only one science communicator in our sample thinks that YouTube is very meritocratic. They recognize the importance of being promoted by a more successful communicator for a channel to earn subscribers, a factor that is indeed not only linked to the internal quality of a channel but also to the network built by the creator, which may be weak for institutional channels. Another interesting fact is that very few channels were created in the last three years. This could suggest a fierce competition where channels established earlier are preventing smaller ones to grow and become known, or be created in the first place. This competition does not have to be direct: it could be that viewers are satisfied with the content they currently watch and have stopped searching actively for new channels. It could also simply reflect the fact that recent channels had less time to grow for us to know about their existence and for them to know about our attempt to identify them, and were therefore not included in our sample.

Since we only analyzed French-speaking channels, it is interesting to ask whether our results can generalize to science communication worldwide. There are certainly several structural differences introduced by the size of English-speaking YouTube and the different (working) conditions in the corresponding countries. Because our sample of individual communicators was based on language and not country, it is difficult to identify a "French culture" that would apply to every communicator in our sample. Indeed, although 90% of our sample reports living in France, a few communicators live in other countries where French is an official language, such as Belgium, Canada or Switzerland. If we focus on France though, the country spends a percentage of GDP on research and development that is close to the average in the European Union (World Bank, 2018), and the country hosts some of the world's leading research institutions such as CNRS (Crew and Jia, 2020), suggesting a general interest and knowledge in science, at least at the institutional level. On the other hand, France has very few science shows on TV and science is generally poorly represented in the mainstream media. It is difficult to say what this peculiarity implicates for Youtube: French people could either watch more science on the internet because they can not find this type of content on TV, or they could watch less science on the internet because they have not been familiarized enough with this topic while growing up. Another difference between France and other countries could be in the availability of public funding: for instance, since 2017, an agency of the Ministry of Culture is funding videos created for the internet specifically

(CNC, 2017). Although this financial support is not targeted at scientific content in particular and is difficult to obtain, it could make a difference in the long term. All these aspects could be investigated in a cross-cultural comparison, but the lack of studies in other countries makes this comparison difficult at the moment. As noted before, at least when it comes to broad demographics such as age, gender or education, our results go in the same direction than previous studies (Muñoz Morcillo et al., 2019; Velho et al., 2020).

Our study was able to provide novel quantitative insights, but our sampling process was constrained by several limitations. First, although our sample was meant to be focused on French-speaking channels generally, it is biased toward France-based institutions specifically. For example, French-speaking institutions in Québec, Canada, were not included in our sample. Second, it is possible that we overlooked some individual and institutional channels, although our sample was made as comprehensive as possible, incorporating both small and big channels. For institutions, we compiled a comprehensive list of science-related institutions before checking whether they even had a YouTube channel; for individuals, we combined online, social, institutional, and personal resources to identify channels. This approach led to our sample containing a large proportion of small channels with less than 1,000 subscribers, thus limiting any selection bias toward highly popular channels. Third, our survey response rate was 29%, further introducing bias into our results, with institutional science communicators being underrepresented. Fourth, our results are influenced to some degree by our initial definitions of “science communicators”, “scientific disciplines”, and “institutions”. The literature offers narrower and broader understandings of “science communicators” (cf. Casini and Neresini, 2013; Baram-Tsabari and Lewenstein, 2017), but because we expected a diverse set of actors (with often unclear or multiple roles) to communicate about science on YouTube, we did not, for example, differentiate between scientists and professional science communicators. Relatedly, there is also no universal definition of an “institution”. The three lists we used to generate our institutional sample cover universities, research institutes and scientific outreach organizations in France. It is unclear which characteristics media outlets such as science magazines would display in such an analysis. We also cannot eliminate the possibility that some institutions blurred the line between institutions and individuals by hiring individual science communicators to present their videos. Finally, only the topic of a channel was assessed to classify them as scientific or not. No additional criteria such as accuracy or adherence to the scientific consensus were defined. This limitation is justified by three main reasons. First, content characteristics were not the focus of our analysis. Second, we wanted to focus on the user experience to construct our sample, and viewers are exposed to both accurate and inaccurate content. Third, determining a correct level of accuracy is a difficult task, especially since science communicators often have to make many approximations in their explanations. In order to facilitate further studies using different definitions, we provide our full database of channels as

well as code necessary to gather data or run the analysis (see Masselot, 2020).”

CONCLUSION

YouTube is one of the most important communication channels and it hosts a large number of science-related content (Burgess and Green, 2018; Allgaier, 2020). Research on science communication on YouTube, however, is still in its infancy and is mostly focused on content and audiences (Allgaier, 2020). The few studies that looked at the communicators did so by extracting information about them through content analyses, and they did so in samples limited to highly popular channels (e.g., M. C. Erviti and Stengler, 2016; Muñoz Morcillo et al., 2019).

The present study looked at an extensive sample of 622 French-speaking science YouTube channels and used a survey ($n = 180$) as well as publicly available channel data (all 622 channels, including 70,795 videos). Our results described the sociodemographics, resources and goals of the science communicators behind these channels (RQ1), as well as the characteristics and performance of their channels (RQ2). It further differentiated these descriptions between individual and institutional science communicators (RQ3).

Results showed that French-speaking science communicators on YouTube are mostly young, male, highly educated, and usually talk about their topic of expertise. Most of them work alone on their channel, do not earn enough money to make a living out of this activity, and have to invest money and personal/institutional resources to run their channel. At the same time, many are not interested in making science communication on YouTube their main source of income. Their main goal is sharing science and stimulating curiosity, as opposed to teaching and entertaining. Together, they are able to cover a lot of scientific disciplines, with individuals usually focusing on a couple of fields and institutions talking about more diverse subjects. Institutions also have a supplementary goal: to promote and present the institution itself. This broader editorial policy could explain why they seem to have relatively less success than individuals in terms of raw number of subscribers and engagement. Other factors that could explain this difference include a different number of videos produced per year and the fact that institutions, by definition, are unable to showcase a personality as strong as individuals. Looking at the channels, we saw that channels of individual science communicators tend to have more subscribers, views per video, and engagement. Nonetheless, institutional channels might have higher potential for success because they get more views per subscriber and can rely on their institution’s funds without needing to be profitable. This reflects the science communication landscape more generally, where institutions become more and more visible as they are increasing their focus and resources on science communication (Vogler and Schäfer, 2020).

Although not without limitations, our study indicates relevant questions left for future research. Our study focused on descriptive results, as very little was known about science

communicators on YouTube, but later studies could try to test our findings by working with hypotheses, e.g., regarding differences between individual and institutional science communicators, or by applying different definitions of “science communicators”, “scientific disciplines” or “institutions” respectively. They could also try to advance the field and link survey-based channel insights with different measures of channel success (e.g., views or number of interactions). Another aspect that deserves to be investigated more is whether the trend we observed of no new channels created in the last three years will persevere. More fundamentally, it would be better if similar research on the production side of YouTube used a theoretical foundation in the future. Approaches such as structuration theory to investigate communicators goals and roles (Giddens, 1984), intermedia agenda-setting to analyze dynamics between communicators (e.g., Lim, 2011), and even the uses and gratifications theory to explore the reasons why communicators chose YouTube could be applied (e.g., Langstedt, 2013).

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession numbers can be found below: <https://github.com/PierreMasselot/Frontier-FrenchScientificYoutube>.

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ETHICS STATEMENT

Written informed consent was obtained from the individuals for the publication of any potentially identifiable images or data included in this article.

AUTHOR CONTRIBUTIONS

All co-authors designed the study and survey, and wrote the manuscript. SD collected the Youtube data. PM analyzed the survey and Youtube data.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fcomm.2021.612667/full#supplementary-material>.

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

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