

SCIENCE POPULARIZATION VIDEOS BY INDEPENDENT YOUTUBE CREATORS AND USER'S APPROPRIATION STRATEGIES: QUALITATIVE ANALYSIS OF USER COMMENTS

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Abstract

The popularization of science through audiovisual media is not a new concept. Specialized television channels that began airing in the eighties and nineties, such as Discovery Channel (1985), History (1995) and National Geographic (1997) are known worldwide. Through their production of high quality content, they have become a major reference when it comes to communicate Science, History, Technology, Biology, and many other academic fields. Inspired by these role models; independent YouTube creators emerged and became big hits by popularizing science through their videos, which have different narrative structures from those of traditional television networks. Their success is backed by millions of views and subscribers, but most importantly, by having active comment sections on which users share their thoughts on the information presented and discuss among themselves. Modern media platforms are often branded with prefixes such as 'inter', 'trans' or 'multi'; which do not necessarily describe the communicational processes and the capacity of modern receivers to intervene, question, and critique the audiovisual narrative and information proposed by these senders.

Whereas traditional media only had to worry about sending a message through unidirectional channels, the receivers of these online contents can, albeit sometimes asynchronously, give meaningful feedback. This is useful if the sender wishes to test how the message was understood, and what can be done to further improve their narrative. But how do receivers interpret this information? This study first took a sample of (5) videos belonging to some of the most subscribed independent YouTube creators, chosen due to the diverse audiovisual narrative and themes they each employ. The YouTube creators and videos chosen are:

- 1 'Veritasium' and the video titled 'Surprising Applications of the Magnus Effect'. This video has 34,536,283 views, 1,998 comments, 76,178 likes and 859 dislikes.
- 2 'Vsauce' and the video titled 'What If Everyone JUMPED At Once?' This video has 24,765,085 views, 37,703 comments, 259,282 likes and 8,268 dislikes.
- 3 'Kurzgesagt' and the video titled 'Addiction'. This video has 12,118,139 views, 13,335 comments, 281,892 likes and 3,708 dislikes.
- 4 'minutephysics' and the video titled 'Immovable Object vs. Unstoppable Force - Which Wins?'. This video has 10,855,019 views, 12,210 comments, 74,773 likes and 2,958 dislikes.
- 5 'CGP Grey' and the video titled 'Humans Need not Apply'. This video has 8,409,251 views, 25,126 comments, 180,332 Likes 3,416 and dislikes.

The comments were then extracted using a web scraping tool that downloaded all the existing comments up to the moment of extraction (subsequent interactions not measured). The sample (90,372 comments) was filtered using data analysis software, in order to discard trolling, hate speech and unrelated comments, whilst prioritizing those which got replies and sparked discussion between users. Based on the qualitative analysis of the comments (and their replies), diverse hermeneutic categories are now being identified, along with users' appropriation strategies, providing an insight on how these users interact on the comment section. This effort is part of a larger study whose objective is to develop a methodology that allows Colombian universities to create high quality science popularization content. We hope the findings can expand modern discussions about online science communication.

Keywords: Popularization of Science, YouTube Video, Comments, Audiovisual Narrative, Appropriation Strategies, Qualitative Analysis.

1 INTRODUCTION

Science as a narrative has sparked a debate similar to the one 'culture' as a concept sparked on the 20th century, where the criteria that catalogued culture as being either vulgar or refined emerged. Today, the debate, centered on the different levels of scientific validity are implicit in any action regarding scientific communication. This pits traditional scholars versus enthusiastic youngsters that want to popularize science through audiovisual media, mainly in the sphere of social media.

In this study, we have resolved to analyze the comments of YouTube users, which consume audiovisual content, specifically scientific popularization videos, produced by independent 'Youtubers', which have passionately assumed the task of communicating science to the new generations. As Boris Groys [1] states, these efforts, considered by some as a 'desacralization' of science, can be compared to the concept of 'transmutation' of older thoughts, which means, it's just enough to re-tell what has already been told, for it to be considered 'innovative', and it is precisely, on this repetition, that the concept of 'the new' resides.

We approached this subject by contrasting the characteristics of this population that consumes science popularization videos on the Internet, with the traditional ways of audiovisual communication that mass media have; in order to analyze the appropriation strategies of the users when encountering scientific communication through YouTube videos.

1.1 Science popularization through audiovisual media

This concept of communicating science through videos is not something new. Starting in the 80's and 90's, channels such as Discovery Channel (1985), History (1995) and National Geographic (1997) have now become worldwide references in scientific popularization. These channels set a standard for producing high quality content pertaining almost all academic fields. Inspired by these giants, young content creators have found success by producing original content through digital media. Using widely different audiovisual narratives –sometimes completely opposite from those of traditional media- they have become prominent figures on YouTube, amassing millions of subscribers.

Long gone are the times where using VHS tapes in the classroom was considered a novelty, and where the students and teachers were the main target for these types of scientific videos. It is precisely due to the rise of digital media, that scientific popularization migrated from closed circuits to a massive dissemination, mediated through different screens. YouTube has become one of the main platforms for audiovisual content, and thus exerts a great deal of influence over the ways content is produced. The logic of its success is measured in views, likes, shares, and finally, asynchronous communicative expressions, or comments, which are the focus of this study.

This platform differs from traditional channels by granting creative freedom in content production. By having fewer restrictions, unlike those of traditional television, YouTube becomes a place of audiovisual experimentation, where almost every content has its place, as long as it can resonate with a specific audience; which is still a leftover characteristic from traditional mass media: measuring audiences to capitalize on advertisement revenue. From that perspective, YouTube is a mix between an iconic cultural figure, acting as a gatekeeper, and a new superstar of the digital age.

1.2 YouTube: a new audiovisual space

The irruption of the 'new screens' generated new audiences and consumers of digital media; which gave way for new business models to rise within the audiovisual industry. This means that due to the popularity of YouTube, new content creators emerged, which were not afraid to experiment with new formats and themes. Unlike mass media, these videos get commented instantly, which shapes the way every video is perceived; not as a standalone product, but rather as a collaborative work, which is open for debate, and facilitates the discussion between strangers, regarding any given themes or messages the video presented. We can also observe that the intended message of the video is complemented by the reactions it gets. Those who comment on YouTube videos are adding a new cultural dimension, born from the discussions between users about the audiovisual text presented.

This notion of an open or collaborative work is 'the new' that Boris Groys [2] proposes. This media platform performs a big role in the entertainment industry, and has not fully separated of those business practices of the traditional mass media. At the same time, YouTube's status as a 'new media' has allowed it to converge different contents from both television and cinema industries, whilst simultaneously promote content exclusive for the Internet.

Most of content creators that work through this platform are interested in producing contents that would not normally reach audiences of traditional television. But it is those independent, low budget creators, the ones who produce the most popular scientific content. We set our sights on the interaction processes of those who comment on these particular scientific videos, whilst not being tight knit virtual community. Each comment has the possibility of being replied to, by anyone on the Internet, and this can lead to either dialogue or debate, which is centered on the themes the video proposed. This transcends the dichotomy of like – dislike on a video as being the most relevant measure for any creator.

1.3 Cultural trends of communication in era of ‘little sips’

One of the first observations the communication scholars made about the emerging cultural practices associated with Internet consumption is that of associating them with Leisure. That notion became one of the first categories of analysis on this sub-field, and was first used to criticize how the use of public spaces and group activities shifted towards progressively smaller screens, which brought to light different processes of disconnection regarding traditional cultural and family practices that are now mediated by the Internet.

Following this trend, García et al. [3] interpret Leisure on the Internet in the following way: ‘not as being connected (online leisure) versus not being connected (offline leisure); and not as virtual leisure versus a real leisure, but rather as new spaces where one can continue with social relationships’. In contrast, the psychologist Sherry Turkle [4] narrates the opposite perspective on her TED Talk: ‘I was caught off guard when Stephen Colbert asked me a profound question. He said, "Don't all those little tweets, don't all those little sips of online communication, add up to one big gulp of real conversation?" My answer was no, they don't add up.’

We believe that experts in communication and linguistics are starting to take notice that there are new ways of communication in this era of ‘little sips’. This asynchrony in communication will most likely be even more prominent in the future, and the longer we keep criticizing these cultural practices, the longer it will take us to understand these asynchronous ways of communication the technological mediation has brought to the table.

2 METHODOLOGY

This study is qualitative in nature, and applies Dilthey's [5] proposal of textual analysis from a hermeneutic perspective. He defends the validity of textual interpretation for both the natural sciences and the ‘sciences of the spirit’ or *Wissenschaften*. For Dilthey [6] ‘the art of interpretation has been progressing steadily, with as much regularity and slowness as, for example, the questioning of the nature in the experiment’. We also incorporated Sleichmacher's [7] proposals, highlighting the notion of *Kunstlehre* or the ‘doctrine of the rules’, which must be taken into account when analyzing a text. Both authors propose a methodology that keeps in mind context and historical experience when interpreting a text. For Grondin, who explains Dilthey's work, this approach is defined in the following way: ‘Hermeneutics is based on dialectics: interpreting a text means to converse with it, ask questions from it, and let it raise questions as well’ [8].

Once we defined how to analyze the comments, we proceeded in selecting the sample size. We first conducted a media monitoring, to find out which were the most recognized independent Youtubers that communicated science. We determined this by measuring the number of subscriptions, which were, in many case, higher than well-established companies have on the same platform. These creators achieved this, despite not investing heavy sums of money during their production process. We will not analyze the reason for their success, as our focus is in analyzing the appropriation strategies of their subscribers; but we urge researches to tackle that topic, as it could lead to defining optimal strategies for scientific communication.

We then chose those independent creators that had the most number of subscribers, and chose a heterogeneous sample that highlighted different styles of audiovisual narrative. Among those styles, we find cartoon animation, video blogs, video essays, and analog animation. We did this in hopes to see if there were differences in percentage or usage of appropriation strategies in depending the style of audiovisual narrative. The initial sample size are 5 YouTube videos that belong to various independent creators, who, from different styles and perspectives, devote themselves to popularizing science. In order to keep data size manageable for analysis purposes, we limited ourselves the sample to five distinct creators, and chose their most popular video, measured by quantity of views,

likes and comments. We extracted this data on February 02, 2017, and did not update it with new comments, in order to have a stable sample size. By using a web scraping tool, we downloaded all the interactions pertaining to each video, and organized them on an Excel Table format, which facilitated the data analysis. The videos chosen were as follow:

- 1 From the channel *Veritasium*, we selected the video ‘Surprising Applications of the Magnus Effect’. This video with a documentary style video, which explains the physical reactions that occur when a spinning motion is added while shooting a spherical object. This tends to curve its trajectory. By linking various clips and animations, the narrator explains the circumstances on which this effect does occur, and highlights its relation with sports as well as other theoretical applications.
- 2 The video ‘What If Everyone JUMPED At Once?’ from the channel *Vsauce* was also selected. This video blog explores, from a multitude of academic perspectives, the popular belief that humans could cause an earthquake if we all jumped simultaneously. It is important to highlight that *Vsauce* is one of the most popular science communication channel on YouTube, and it even has secondary channels with different hosts, called *Vsauce2* and *Vsauce3*.
- 3 *Kurzgesagt*, which also means ‘to put it simply’ in German, is a channel dedicated to simplifying complex themes, by illustrating them with stylized, colorful animations. Through these cartoons, debates relevant to sensible topics are discussed. A prime example of their work is the video ‘Addiction’ that puts in perspective all of our pre-conceptions about what is considered addictive in our society.
- 4 The channel *minutephysics* is the channel that produces the shortest clips, but at the same time, deals with complex physical and mathematical conundrums. Their content is usually analog animations on a blackboard, which is then sped up, and explained by a narrator. On their video ‘Immovable Object vs. Unstoppable Force, Which Wins?’ they explore, from quantum physics perspective, the notions of immovable and unstoppable.
- 5 Finally, belonging to the channel *CGP Grey*, we selected the video ‘Humans Need not Apply’, which is a video essay that explores the evolution of machinery, how it revolutionized society and our lives, and explains the many challenges yet to come, when Artificial Intelligences inevitably replace many of our existing jobs.

From the original data set, we excluded those comments which did not have replies, filtering out the empty cells and the ‘false’ variables of the ‘Has Replies’ column. Then, we applied a function that counts the number of characters on the two most important columns: Video Comment and Reply Comment. By filtering out responses that were below 140 characters (same as the Twitter standard for making a concise argument), we made sure to exclude as many emotional or non-argumentative comments as possible.

Once these filters were applied, we did a manual revision to the filtered sample, and eliminated comments that were not relevant to the discussion centered on the video’s topic. Finally, we numbered each reply using a simple function, in order to use an online tool that would calculate a random sample for us to analyze. We started with an average of 100 comments per video, generating a random set of numbers in order to choose which comments to analyze. We did this for each video until we reached a data saturation, following the methods listed by Palinkas et al.[9]. If data saturation was not reached after 100 comments, we selected another random data set and analyzed until we considered no more relevant data could be found. The data analysis was done following the hermeneutic focus proposed by Dilthey[6]. Based on our revision, emerging categories were found, and the user’s appropriation strategies were defined.

3 RESULTS

After finishing the analysis process, and based on the hermeneutic approach, we found emerging categories that were contrasted and applied to the rest of the comments. Each appropriation strategy is listed, along with specific comments from each video.

3.1 Inquiry

Inquiry: The individual formulates a question, based not only on the information presented in the video, but keeping in mind different sources or themes as well. This exercise transcends the mere notion of not understanding the procedure or information at hand. This means that the user doubts regarding how the information presented in the video is applied to a specific context or situation, whether real or hypothetical.

Table 1. Inquiry

Video creator	Comment # (for randomization)	Type of Reply	Category	Comment
Vsauce	520	Reply to video	Inquiry	'Correct me if I'm wrong, but I did this calculation. I wanted to figure out about how many people would have to jumps at once to equal the magnitude of the 2011 Japanese earthquake from 1 and a half km away. I did this: $(9 / 0.6) * 50000$. I got the answer of 750000 people. So, why would it take so many people like Michael said?'
Veritasium	75	Reply to video	Inquiry	'+Veritasium If electrons are "flying" around core isn't it perpetuum mobile? Will they fly forever? Or will they explode? :D'
C.G.P Grey	2626	Reply to video	Inquiry	'One question: when the futurists say that the new technologies will replace or make disappear certain jobs, why do they always and systematically pinpoint the low-paying and dead-end precarious and mechanical jobs, instead of CEO, President, Prime Minster or some sorts? Is it a ritual of some sorts of spitting at these grease or entry-level jobs, without say a single thing about high-profile position? They do that because they fear this will jeopardize their funding, and "give them what they want" because those 'dirty jobs' are literally not worth to be survived?'
Kurzgesagt	2049	Reply to video	Inquiry	'Couldn't it be argued that the need for connection to other people is just another form of addiction? Becoming dependent on other people to fulfill our lives. In the end we are dependent on a lot of things, some more harmful than others.'
minutephysics	54	Reply to video	Inquiry	'How can fermions pass through each other I mean it would require two of them to be at the same space coordinate at the same time? For large object when there is an impact shouldn't there be momentum change? I mean sure with immovable and unstoppable it means that the one that budges is not what their title holds but I think that is the point. In a universe with our laws of physics there can't be 2 object with so high inertia that it can't change its trajectory regardless of external acceleration. If it dies and both run into each other we might just see some extreme scenario that might tear our fabric of physics.'

3.2 Comparison

Comparison: The individuals associate the knowledge gained from the video, with previous data from different sources, and link the two of them to make a compelling argument. The comparison is usually a comment without a defined recipient, and the individual usually seeks to showcase how they understood and linked the knowledge obtained with previous information.

Table 2. Comparison

Video creator	Comment # (for randomization)	Type of Reply	Category	Comment
Vsauce	294	Reply to comment	Comparison	'If they were in the same area for example LA then the result would be catastrophic but if they were from 10 different locations in the world then the damage would be less but could cause mini earthquakes.'
Veritasium	95	Reply to video	Comparison	'Interesting that the actual deviation (of the basketball) is so large. The explanation using Bernoulli's principle is simpler.'
C.G.P Grey	984	Reply to comment	Comparison	'But what scares me about automation is the degrading level of skill of people. They say practice makes perfect and on the other side of the coin, us Christians have a saying that idle minds are the devil's playground. When all the thinking and lifting and working can be done for us, we won't need a Terminator-style apocalypse to destroy our civilization. We might just end up as the human blobs in Wall-E.'
Kurzgesagt	1830	Reply to comment	Comparison	'Porn addiction is becoming increasingly common though, it can be very addictive. If you feel like its becoming a problem, then there's no shame in seeking help. Good luck and best of wishes :)'
minutephysics	293	Reply to comment	Comparison	'+Tom Manchester well, if you take Newton's 3rd law, for every action there is an equal and opposite reaction, then technically if there were to be an "unstoppable force" then an "immovable object" would exist'

3.3 Feedback

The user is able to respond to the video creator, and clearly explain the information to other users, based on the video's information, and combined with previous knowledge; they can summarize the information and deliver it in a concise, simple way. They often raise more questions that beg answer.

Table 3. Feedback

Video creator	Comment # (for randomization)	Type of Reply	Category	Comment
Vsauce	110	Reply to comment	Comparison	'If they were in the same area for example LA then the result would be catastrophic but if they were from 10 different locations in the world then the damage would be less but could cause mini earthquakes'
Veritasium	243	Reply to comment	Feedback	'+nothintoseehere.jpg' What John Smith said. With no backspin the BB's would simply drop under gravity, by giving them backspin they lift up which counteracts gravity, and makes them 'fly' further.'
C.G.P Grey	626	Reply to comment	Feedback	'No because ur already in the state of moving 100miles an hour with the train so when u jump ur going 100miles an hour but u do slowly lose speed when u jump because ur no longer getting propelled but to be able to move from one part to the other ur gonna have to have some insane hang time to be able to decelerate to make a difference on where your standing'

Video creator	Comment # (for randomization)	Type of Reply	Category	Comment
Kurzgesagt	2325	Reply to comment	Feedback	'+cadr003Â Actually it's neurologically similar (addiction wise some argue love is stronger than heroin), but love leads to a close bond and sex (which are healthy), while heroin does not.'
minutephysics	14	Reply to comment	Feedback	'SeaB ForYou Not to mention the logic is completely flawed. In order for one mass to travel through another either there is a change in velocity as the mass from each object avoids each other and there is thus acceleration or the mass directly collides causing either chemical reactions or atomic fusion to occur. Either would cause the destruction of the objects...'

3.4 Deliberation

The user is able to, not only to understand the video, but also to replicate the information to see if the method works, whether physically, or theoretically. These users show prowess in critical and abstract thinking. It is also possible to adapt the new data to that narrative.

Table 4. Deliberation

Video creator	Comment # (for randomization)	Type of Reply	Category	Comment
Vsauce	757	Reply to comment	Deliberation	'I don't think we have enough airplanes.... the standard jumbo jet only holds around 400 hundred people and there's probably only a few thousand of them. So we could probably only get around 1,000,000 (give or take a few hundred thousand, doing some rough math here) on a plane at once which is around 1/7000 of the 7,000,000,000 people on Earth, and even if we could our mass would still be so insignificant compared to the Earths that it would probably only affect the rotation of the Earth by a few nanoseconds. Also a shit ton of people would die because that many planes in the sky would not turn out well...'
Veritasium	70	Reply to comment	Comparison	'+Veritasium Sports science did Masahiro Tanaka. He's an excellent example of the Magnus Effect because he places around 3000 rpms of backspin on his 4 seam fastball and his main variation is taking that off by altering his fingers.'
C.G.P Grey	384	Reply to video	Deliberation	'I think it isn't likely to happen. Working in an office is now by far the most populated job. If those people do not generate income there will be nobody able to buy large companies products and eventually the enterprise will collapse.'
Kurzgesagt	1821	Reply to video	Deliberation	'Interesting video. But It didn't explain the science behind addiction, how several chemical react with our body, such as dopamine level inside our brain or something else. I think that's necessary. Because instead of just inform people that chicken came from egg, it would be better to inform people how the egg became a chicken, in a nutshell as always. But overall this video is very great. It shows different perspective that lots of people don't realize. Keep making great videos..'

Video creator	Comment # (for randomization)	Type of Reply	Category	Comment
minutephysics	371	Reply to video	Deliberation	<p>'False!</p> <p>An unstoppable object (U) and an immovable object (I) would both have the same amount of inertia. Exactly infinity! Infinite forces, but equal nonetheless!</p> <p>Picture U and I as cubes of equal mass, size and shape. Now picture U on a collision course towards I. Due to the forces being equal (U having infinite dynamic inertia, and I having infinite static inertia), they would simply collide and switch properties! U would become I, and I would become U. Much like a Newton's Cradle.</p> <p>Yes, U would no longer be unstoppable, and I would no longer be immovable.</p> <p>But Newton doesn't lie! And solid objects certainly don't pass through each other...'</p>

4 CONCLUSIONS

The amount of subscribers that actually engaged in a meaningful, scientific discussion was lower than predicted. If we look at the final filtered sample sizes, we realize the percentage of the total population that discusses the information relevant to the video is extremely low. From the Kurzgesagt's video we had a sample of 2410 meaningful comments (18,07% of all comments), which was the highest response ratio, compared to Veritasium's 252 comments (12,61%), CGP Grey's 3076 comments (12,24%), minutephysics's 837 (6,85%) and Vsauce's 812 comments (2,15%). This suggests that, while there are users who actually engage in a meaningful scientific discussion, they are the minority. These findings could be used to evidence the actual impact these videos have, but we would need more data to confirm that, besides the fact that not all of the users comment on the videos. What we can confirm is that the comment section is a public space open for debate, albeit filled with trivial information.

A redeeming feature we found, is that the level of the discussions that do exist is actually quite complex, with professionals, researchers, students, and professors all interacting with each other and explaining difficult concepts to an audience that seems eager to learn. These users are building ephemeral communities that are a fascinating object of study for any researcher in the social sciences. We acknowledge also found that multidisciplinary videos have a broader audience, represented in the number of views and likes, but do not necessarily have the most meaningful and complex discussions. For example, Vsauce's video is the one with most views, but does not have higher ratio of meaningful comments to total comments (though it has higher number of comments).

The four emerging categories are represented in all of the videos, with Feedback being the most prominent, since users tend to respond to each other, rather than just state their personal conclusions as a reflexive exercise. Most of the comments associated with Deliberation came from well-educated individuals, some of who reported being doctoral students or already having a PhD in the subject pertaining the video. In contrast, the Inquiry and Comparison categories were hinted to belong to high school or college students seeking to understand complex topics, and finding an ideal place to ask questions or reach conclusions based on the interaction of other users and the information given by the video. These findings should be relevant to local universities, which, according to Inciarte-González et al. [10], 'have to continue being the crossroads of all ways of thinking, especially critical thinking'. Institutions should take note of these discussions to further integrate the new digital media into the classroom. The comment sections of these videos are, despite their asynchrony, spaces of meaningful communication between subjects, both public and academic, and they should be studied further.

Even though all of the videos were on English (some have subtitles), that does not necessarily mean all users are from English speaking countries, since many reported living in developing countries. This is another variable to be considered in any future study; determining the country of origin of users that consume these types of content, and whether their social realities affect in any way their consumption

or preference towards the contents. We hope this work can be used as reference to design curriculums or scientific popularization strategies that keep in mind the type of appropriation strategies the recipients utilize to incorporate that knowledge to their daily lives.

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