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ARTICLE

Engaging science: audience perceptions of informal science communication on Arabic YouTube channels

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Abstract

This study investigates the emotional and cognitive responses of Arabic-speaking audiences to informal science communication on YouTube. Focusing on three prominent Arabic YouTube channels that provide science content, @Da7ee7, @NidhalG, and @Espitalia, the study analyzes their communication styles to explore how stylistic differences shape audience engagement and perception. The study classifies the channels into three distinct communicative styles; humorous, academic, and conversational to examine variation in audience responses. Employing computational content analysis, the study applies LDA topic modeling and sentiment analysis to examine emotional and cognitive engagement in user comments. Results show that humorous content is associated with stronger positive emotions and cognitive activation, whereas academic and conversational styles evoke more mixed reactions. Topics like space science and artificial intelligence elicit complex emotions such as confusion and admiration. Addressing a key gap in Arabic-language science communication, the study reveals how style and topic shape public engagement in culturally specific digital spaces.

Keywords

Public understanding of science and technology; Popularization of science and technology; Public engagement with science and technology

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1 ▪ Introduction

Science communication has undergone a significant evolution, transitioning from formal, institution-centered dissemination to more accessible and engaging approaches. Traditionally, science communication focused on formal education and scholarly outputs, often positioning the general public as passive recipients of expert knowledge [Bucchi, 1998]. However, the past two decades have witnessed a shift towards informal science communication, which encompasses learning experiences outside formal settings, such as museums, science centers, media, and increasingly, digital platforms [National Research Council, 2009]. This shift aligns with the growing recognition that people spend more of their time engaging with science through everyday experiences and media rather than within formal education systems [Bell et al., 2009]. This broader transformation has prompted deeper reflection on the changing aims and practices of informal science communication.

Bucchi, for instance, [1998] argue that informal science communication is not merely a response to poor media coverage or public misunderstanding; it reflects deeper societal transformations, including the public's desire for more participatory and engaging scientific dialogue. Informal venues enable interactions that are learner-centered, voluntary, and shaped by cultural and social contexts [McCallie et al., 2009]. This evolution has led to models like public engagement with science (PES), which emphasize dialogue, mutual learning, and co-creation of knowledge between scientists and the public [Shirk et al., 2012]. In contrast to traditional public understanding of science (PUS) models, PES fosters interactive and culturally resonant approaches to science communication, facilitating emotional and narrative engagement [Lewenstein, 2009]. Despite this global shift toward engagement-focused models, much of the scholarship remains geographically concentrated.

Although science communication has expanded globally, its theoretical foundations remain largely Western [Guenther & Joubert, 2017; Navarro & McKinnon, 2020; Turner et al., 2024]. In the Arab world, research has mostly focused on institutional science journalism through professional or media-centric lenses [Alhuntushi & Lugo-Ocando, 2023; Mellor, 2024], with limited attention to informal science communication, particularly from the audience perspective. No systematic studies to date have analyzed how Arab viewers cognitively or emotionally respond to science content on platforms like YouTube. This gap makes it necessary to consider how audiences in the region engage with science through digital media.

Given high mobile and internet penetration in the region [Arab News, 2025], YouTube has become a key platform for science communication, especially among youth [Barqawi et al., 2023; Abu Backer & Awad, 2025; Stanger et al., 2017]. The Arabic digital sphere is shaped by linguistic diglossia, varied scientific literacy, and sociopolitical sensitivities, which affect both communication and interpretation [Musleh et al., 2023]. YouTube's support for long-form, visually rich, and algorithm-driven content allows for unique audience engagement in this context. Thus, Arabic YouTube should be seen not as a localized version of a global platform, but as a distinct communicative space with its own stylistic and cultural dynamics [Kraidy & Khalil, 2008]. Within this space, stylistic features such as humor, emotion, and storytelling become especially important.

Yet, the gap is evident when considering the role of humor, emotion, and storytelling, as this communication formats are highly context-sensitive and culturally mediated [Dahlstrom &

Scheufele, 2018]. Such impact depends not only on the medium but also on the character, audience norms, linguistic expression, and socio-political sensitivities, which differ markedly between Western and Arabic-speaking contexts. As such, examining how these elements function in Arabic informal science communication is crucial to understanding their impact on audience engagement and perception. To address this need, the present study applies computational tools to analyze Arabic science communication online.

Therefore, study responds to the gap in understanding informal science communication within Arabic contexts by employing computational methodologies, including Latent Dirichlet Allocation (LDA) topic modeling and sentiment analysis, to analyze how Arabic-speaking audiences perceive and emotionally respond to scientific content on Arabic YouTube channels. Through this approach, the study captures both stylistic patterns and audience reactions in a culturally specific digital environment.

By analyzing audience interactions, this study shows how informal Arabic science communication on YouTube blends learning and entertainment, advancing both science literacy and public engagement in the Arab world. It focuses on audience engagement, measured through emotional and cognitive responses to different communicative styles. The study contributes in two ways: first, by addressing the lack of research on informal Arabic science communication and offering insights into how audiences emotionally and cognitively engage with digital science content; and second, by applying computational methods to examine how digital media and style shape public participation in science communication.

The paper begins by outlining the theoretical framework, focusing on humor, emotion, and narrative in informal science communication. It then explains the computational methods used to analyze audience comments, followed by findings on thematic patterns and emotional responses. The discussion interprets these results within existing communication theories, highlighting cultural contexts. The conclusion summarizes key insights, notes limitations, and suggests future research directions.

2 ▪ Literature review

2.1 ▪ *Evolving models of science communication*

This review adopts a non-systematic approach, drawing from studies based on thematic relevance and conceptual alignment with the study's objectives. The landscape of science communication has undergone a significant transformation from early deficit models of knowledge transmission to more complex, participatory, and culturally nuanced practices. This shift is especially pronounced in informal settings, where traditional boundaries between scientific experts and lay audiences have been challenged [Bucchi, 1998; Gascoigne et al., 2020].

Initially, science communication was often conceptualized through the deficit model, which posited that public skepticism stemmed primarily from a lack of scientific knowledge. Scientists and institutions viewed their role as correcting this "deficit" by disseminating information [Schmid-Petri & Bürger, 2019]. However, critiques of this model, particularly its assumptions of passive audiences, emerged in the late 20th century, highlighting its inadequacy in addressing complex societal issues like climate change, biotechnology, and pandemics [Nisbet & Scheufele, 2009; van der Linden, 2015].

2.2 ▪ *Emotion, humor, and cultural context in informal science communication*

A pivotal development in this evolution was the recognition that science communication is inherently interactive and context dependent. Models emphasizing dialogue and engagement supplanted the linear transmission paradigm. Cheng et al. [2008] emphasize how social contexts shape communicative practices, while Bucchi [1998] introduced the concept of "constitutive communication", where public interaction actively shapes both scientific knowledge and its legitimacy. This participatory ethos was further advanced by digital platforms, which democratized access and blurred lines between expert and lay communication [Franzen, 2019].

The integration of narratives, emotion, and humor into science communication represents another layer of complexity. Dahlstrom and Scheufele [2018] argue that narrative structures, comprising characters, plotlines, and framing, evoke emotional responses, facilitating audience engagement and memory retention. However, narratives may also oversimplify or distort complex scientific information. Their AEIOU framework (Awareness, Enjoyment, Interest, Opinion-forming, Understanding) positions emotional engagement as a legitimate pathway to public understanding [Burns et al., 2003].

Recent research highlights humor as a powerful tool in digital science communication. While earlier persuasion models such as the Elaboration Likelihood Model [Petty & Cacioppo, 1986] viewed humor as a peripheral cue leading to weak, short-term attitude change [Weinberger & Gulas, 1992], recent scholarship offers a more nuanced view [Pinto & Riesch, 2017]. Humor is now seen as cognitively engaging, particularly when framed through the incongruity-resolution model [Suls, 1972], which describes humor as a two-stage process of detecting and resolving contradictions. Studies like Strick et al. [2013] and Yeo et al. [2020] demonstrate that such processing can deepen engagement and enhance perceptions of communicator credibility by boosting both likability and expertise. Once undervalued, humor is now increasingly recognized for its dual affective and cognitive impact in science outreach [Riesch, 2015].

In line with this, Becker and Anderson [2019] demonstrated that one-sided ironic satire on climate change, which demands greater interpretive effort from audiences, facilitates elaboration and counterarguing more than two-sided sarcasm, which is generally more playful and less cognitively taxing. Their study highlights how the type and complexity of humor can shape audience engagement with scientific content.

Crucially, humor's effects are also shaped by sociocultural context. Earlier literature documented variation in humor styles and reception across cultures, often interpreting these differences through surface-level cultural adaptation [Eisend, 2017]. Building on this foundation, a range of socio-cognitive and evolutionary perspectives has since offered deeper structural explanations. Foundational work such as Chafe [1987] conceptualized humor as a disabling mechanism that suspends normative cognitive or behavioral expectations, highlighting its cultural contingency. Subsequent perspectives, including Clarke's [2008] pattern-recognition account, further emphasize cognitive flexibility as central to humor appreciation. These frameworks collectively inform more recent discussions of humor's cognitive and cultural functions, especially in complex communication domains such as science

Eisend [2017] extended this evolutionary perspective by linking the effectiveness of humor to the negotiability of relationships within a society, which he associates with mate selection motives [Li et al., 2009]. In societies with high relationship negotiability, indicated by metrics such as higher divorce rates and fewer arranged marriages, humor is more prevalent in persuasive communication and exhibits stronger persuasive effects. This helps explain the differing success of humorous science messaging across cultural contexts.

This convergence of emotion, humor, and narrative reflects a broader shift toward entertainment-infused science communication; sometimes termed "edutainment" which leverages audience preferences for informal, relatable formats [Jucan & Jucan, 2014; Bucchi & Trench, 2021]. While critics caution against superficial engagement [Scheufele, 2022], proponents argue that these formats can foster inclusivity and public trust, particularly when deployed thoughtfully.

YouTube and social media have transformed science communication into more accessible and participatory experiences. Boy et al. [2020] identify diverse YouTube formats, presentations, animations, and narratives, each affecting engagement and comprehension differently through visual cues and interactivity. Their findings suggest the need for models that address varied formats and attention patterns. Kulczycki [2013] notes that social media democratizes access while blurring lines between expert and public discourse. Yet, these platforms can also amplify misinformation, requiring strategies that balance appeal with accuracy [Schäfer, 2011].

The evolution of science communication has been accompanied by a reconceptualization of audiences. Rather than passive recipients, audiences are now seen as active participants whose identities, values, and emotions shape their reception of scientific messages [Davies, 2020]. Archer et al. [2015] introduced the concept of science capital, extending Bourdieu's framework to illustrate how social and cultural factors influence individuals' engagement with science. Studies show that audience diversity, in terms of gender, ethnicity, and socioeconomic status, intersects with engagement strategies, often perpetuating inequities in access and participation [Kontkanen et al., 2024].

Humm et al. [2020] discusses the emotional dimensions of engagement, revealing that feelings of exclusion, distrust, or inadequacy can hinder participation, particularly among marginalized groups. This calls for inclusive communication practices that prioritize cultural sensitivity and participatory methods [Nguyen & Tran, 2019].

The Arabic-speaking world presents distinct opportunities and challenges for science communication. Online media serve as crucial platforms that bypass traditional gatekeepers [El-Awady, 2007], yet issues such as limited digital literacy, political constraints, and sensitivities around controversial topics persist [Nguyen & Tran, 2019]. Musleh et al. [2023] highlight the cultural and linguistic complexity of engaging Arab publics via sentiment analysis of Arabic science videos. These studies reinforce that science communication is not culturally neutral. Gascoigne et al. [2020] call for context-sensitive approaches that consider local epistemologies and social norms, while Bucchi and Trench [2021] frame science communication as a pluralistic and culturally shaped dialogue.

Despite the burgeoning scholarship on science communication and its evolving practices, much of the existing literature remains centered on Western contexts, with limited exploration of how communicative styles impact audience engagement in non-Western

settings. In particular, studies focusing on the Arab world have largely overlooked the dynamic role of style in shaping public perceptions and emotional responses to informal science communication settings. This study addresses this gap by conceptualizing and empirically investigating the influence of communicative style in Arabic-language science communication on YouTube. By focusing on the interplay between style and audience response, it offers a novel contribution to the field, illuminating how diverse approaches to informal science communication can shape public understanding and engagement with science in the Arab world. More importantly, While computational and sentiment analyses enable large-scale mapping of audience reactions, their interpretive validity depends on contextual and discursive grounding. Therefore, this study integrates computational modeling with qualitative contextualization of communicative practices, ensuring that algorithmic findings are interpreted within their cultural, linguistic, and rhetorical settings. This approach aligns with calls within communication research to balance quantitative scalability with discursive depth and contextual sensitivity.

This study aims to examine how Arabic-speaking audiences emotionally and cognitively engage with informal science communication on YouTube, focusing on the association of different communicative styles and content topics. Building on previous findings that audience emotions vary depending on content complexity and tone, the study develops a stylistic typology; humorous, academic, and conversational to investigate differential audience responses. Specifically, it proposes the following hypothesis:

Hypothesis 1. Humorous communicative styles in Arabic-language science videos will elicit stronger positive emotional responses (e.g., amusement, admiration) but lower indicators of cognitive elaboration (e.g., confusion, questioning) compared to academic or conversational styles.

To further explore the emotional complexity triggered by certain science topics, the study also asks:

Research question. How do different scientific topics and communicative styles in Arabic-language YouTube science videos shape audience emotional and cognitive responses, particularly expressions of confusion, admiration, amusement, and anger?

By addressing these questions, the study aims to contribute a culturally situated understanding of public engagement with science in the digital sphere, emphasizing the role of style and topic in shaping audience response. Given the exploratory aim of this study, the analysis is intended to be descriptive rather than statistically generalizable.

3 ▪ Methods

This study adopts a descriptive and exploratory design aimed at uncovering how stylistic formats shape audience responses within Arabic informal science communication. The intention is not to produce statistically generalizable claims about the entire Arabic science communication ecosystem but to examine three illustrative cases that represent distinct communicative styles. Accordingly, the sampling strategy follows purposive theoretical logic, selecting channels that exemplify humorous, academic, and conversational approaches. This independent study, not part of any thesis or funded project, is motivated by the growing need to understand informal science communication in Arabic digital spaces, particularly on

YouTube. The study adopts a computational content analysis framework encompassing three phases; data collection, preprocessing, and analysis to systematically capture and interpret audience responses to informal science communication on Arabic-language YouTube channels in a rigorous and reproducible manner.

Although Arabic YouTube hosts an expanding landscape of science-related channels, including @Egychology, @dradambat, @NmkosourShow, and @NajibElMokhtari, the absence of a systematic database mapping this ecosystem complicates attempts at comprehensive sampling. Within this broad and diffuse environment, three channels were purposively selected for this study: Al Daheeh, NidhalG, and Espitalia. These channels were chosen because they offer long-term continuity in science-focused content, sustained audience engagement, and clear stylistic differentiation. Together, they represent three dominant modes of informal science communication across the Arabic-speaking digital sphere: humorous edutainment (Al Daheeh), academic-philosophical exposition (NidhalG), and conversational-medical explanation (Espitalia). Their established publishing histories and large viewer bases make them theoretically meaningful cases for examining how stylistic variation shapes emotional, cognitive, and interactive audience responses within informal science communication.

The three channels also differ significantly in content scope, format, and audience scale. Al Daheeh (@Da7ee7), hosted by Egyptian communicator Ahmed El-Ghandour, relies on humor, rapid narration, and cultural references to simplify complex concepts; as of May 2025, it features 218 videos, 2.18 million subscribers, and more than 56 million views. Nidhal Guessoum's academic channel (@NidhalG) adopts a reflective, philosophical approach to scientific and cosmological topics, comprising 387 videos, 558,000 subscribers, and 34 million views. Espitalia, created by medical expert Dr. Iman Imam, delivers accessible health education through narrative storytelling, with 189 videos, 1.27 million subscribers, and over 42 million views. These distinctions provided an analytically productive comparative framework for examining audience perceptions of Arabic popular science content.

The dataset consisted of user comments collected from all publicly accessible videos posted by the three channels between May 2015 and May 2025. The initial corpus included approximately 742,015 comments. After removing duplicate entries, spam, and non-Arabic comments, the final dataset comprised 718,558 comments across 665 videos. Comment volume reflected each channel's reach and activity patterns, ranging from a few hundred to several thousand comments per video. Table 1 presents a detailed breakdown of the dataset composition.

To ensure a comprehensive and methodologically rigorous dataset, this study combined manual contextualization with automated data retrieval. The initial phase involved reviewing curated playlists from the selected YouTube channels. Each playlist was manually organized into a Word document with notes on scientific topics, structural elements, and communicative styles. This step provided essential contextual insight that informed the subsequent computational analysis.

We then implemented an automated extraction pipeline to compile the video dataset. Using a Selenium-based script with a headless Chrome browser [Selenium project, 2024], the scraper dynamically scrolled through playlists to load and capture all video links. It identified URLs containing /watch?v=, extracted unique video IDs, and generated a complete,

Table 1. Dataset composition by channel.

Channel Name	Communicative Style	Total Videos	Total Comments	Average Comments per Video	Range (Min–Max)
@Da7ee7	Humorous/ Edutainment	303	544,791	1,798	15–6,898
@Espitalia	Conversational/ Medical	121	98,345	813	7–4,077
@NidhalG	Academic/ Technical	241	75,422	313	14–1,670
Total	—	665	718,558	—	—

Note: Table 1 summarizes the dataset composition, showing total videos, comment counts, and comment ranges per channel.

non-biased list of videos. This was followed by metadata retrieval via yt-dlp [yt-dlp developers, 2023] to verify accessibility and ensure dataset integrity.

The hybrid approach, manual curation for contextual depth and automation for scale and reproducibility, aligns with best practices in computational media studies [Boy & Crawford, 2021; Ohme et al., 2023]. To retrieve audience comments, we used the youtube-comment-scraper-python library, which allowed structured extraction of public user responses.

In the preprocessing phase, only comments containing Arabic text were retained. Duplicates, spam, and non-Arabic entries were removed. Text was cleaned for punctuation, emoji, and diacritics, then normalized using the Farasa Toolkit [Abdelali et al., 2016], which is optimized for both dialectal and Modern Standard Arabic. Tokenization and stopword removal were performed using the AraNLP library in preparation for emotion and sentiment analysis.

Emotion labeling used the Arabic version of the NRC Emotion Lexicon to identify eight core emotions: joy, trust, fear, surprise, sadness, disgust, anger, and anticipation [Mohammad & Turney, 2013]. This lexicon-based method is validated for low-resource languages, including Arabic [Akhtar et al., 2019; Antoun et al., 2020].

For topic modeling, we applied Latent Dirichlet Allocation (LDA), selected for its transparency, interpretability, and compatibility with theory-driven inquiry [Blei et al., 2003]. Given Arabic's diglossia and tokenization variability, probabilistic models remain advantageous for medium-scale corpora [Abdelali et al., 2016]. LDA's interpretable topic-word distributions ensured conceptual alignment with our study's theoretical constructs, including humor, emotion, and narrative style. Recent research underscores that interpretability- rather than novelty- emains central in topic modeling validity [Hoyle et al., 2021], particularly in Global South contexts where language-optimized embeddings are limited [Nguyen & Tran, 2019].

To complement lexicon-based classification, we also used AraBERT [Badaro et al., 2018], a transformer model fine-tuned for Arabic, to enhance detection of informal and dialect-rich emotional expressions. This hybrid NLP strategy improves both recall and precision.

Comments were then grouped by video and communicative style (academic, conversational, humorous). Statistical analysis included chi-square tests to examine associations between

emotion and style, applying Bonferroni correction for multiple comparisons. Multinomial logistic regression estimated the likelihood of specific emotions (e.g., joy, disgust) occurring across styles, using the conversational style as baseline. Results were reported as log odds and confidence intervals.

All data used was publicly accessible and complies with YouTube's terms of service. No personally identifiable information was collected or analyzed. Ethical standards were maintained throughout, following the guidelines of the Association of Internet Researchers (AoIR) and related discussions on privacy in social media research [Townsend & Wallace, 2016; Williams et al., 2017].

4 ▪ Results and analysis

The analysis of user responses to informal Arabic science communication through YouTube videos by renowned YouTubers reveal distinct emotional patterns across the three stylistic categories examined, academic, conversational, and humorous. Overall, humor dominated the dataset in terms of frequency, accounting for the vast majority of comments, followed by conversational and academic styles.

An initial comparison of emotion distributions revealed that, across all styles, the most dominant emotional reaction was" approval," followed by other positive or ambivalent emotions such as admiration, amusement, and a relatively small proportion of confusion. To verify that these observed differences were statistically significant, a Pearson's chi-square test of independence was performed to examine the association between communication style and emotion category. The result was highly significant, $\chi^2(12) = 735.62$, $p < .001$, indicating that emotional responses varied systematically across styles. Academic and conversational videos contained proportionally more anger and confusion than humorous videos, confirming that style-specific affective differences are statistically meaningful.

Before interpreting the statistical differences across styles, it is important to briefly outline the classification procedure that generated the emotion labels used in the analyses. To ensure validity and reliability, the AraBERT model was evaluated on a manually labeled validation subset of 500 randomly selected comments, proportionally drawn from all three channels. The model achieved strong and balanced performance, with macro-averaged precision, recall, and F1-scores all exceeding 0.80 across emotion categories. In addition, a random sample of classifier outputs was manually reviewed and compared with human-coded examples to verify semantic and contextual alignment. Representative examples for each emotion category are provided in Table 2 to illustrate the classifier's face validity and linguistic accuracy in Arabic discourse. With the classification approach established, the following section examines how these emotion categories vary across communicative styles using statistical comparisons.

And to ensure comparability across stylistic categories, we drew a balanced random sample (n = 75,422 per style) and recomputed the distributions (Figure 1). The proportions were more comparable in this subsample, and the pattern of dominance for approval held consistently across styles. However, within this balanced design, humorous videos retained a slightly higher share of amusement and approval, while academic videos still exhibited comparatively more confusion and anger. These shifts reinforce the stylistic influence on

Table 2. Representative Arabic comments illustrating emotion categories identified by the classifier (manually reviewed).

Emotion	Arabic Comment	English Translation	Channel
Approval	فعلاً الشرح بسيط وواضح جدًا، استفدت كثير من الحلقة	The explanation is really simple and clear	Nidhal Guessoum
Admiration	محتوى علمي راقٍ كالعادة، فخور بوجود قنوات عربية بهذا المستوى	High-quality scientific content as always, proud to see Arabic channels at this level	Da7ee7
Amusement	لما تحاول تدرس بس تنسى نفسك وتضحك على المثال	When you're trying to study but end up laughing at the example	Da7ee7
Anger	ليه دايمًا العلم بيُستخدم لتبرير أشياء ضد الدين؟ هذا غير مقبول	Why is science always used to justify things against religion? This is unacceptable	Espitalia
Annoyance	الموضوع مكرر كثير في القناة، تمنيت طرح فكرة جديدة بدل إعادة التوضيح	The topic has been repeated too often on this channel; I wish they had introduced a new idea instead	Da7ee7
Caring	الله يجزيك الخير على التوعية، فعلاً الموضوع مهم للناس	May God reward you for raising awareness. this topic is truly important for people	Espitalia
Confusion	مش فاهم، يعني التجربة نجحت ولا فشلت؟ وضّح أكثر لو سمحت	I don't understand. did the experiment succeed or fail? Please clarify	Nidhal Guessoum
Positive	أجمل شرح شفته عن النظرية، حسّيت فعلاً إن العلم ممتع	The best explanation I've seen about the theory, it really made science feel exciting	Da7ee7
Negative	الطرح سطحي جدًا وما في عمق علمي كالعادة، كنت متوقع تحليل أقوى	The explanation was overly superficial and lacked the usual scientific depth. I expected a stronger analysis	Espitalia

affective responses, suggesting that even after controlling for volume, humor continues to elicit a more emotionally positive and less cognitively ambivalent user response.

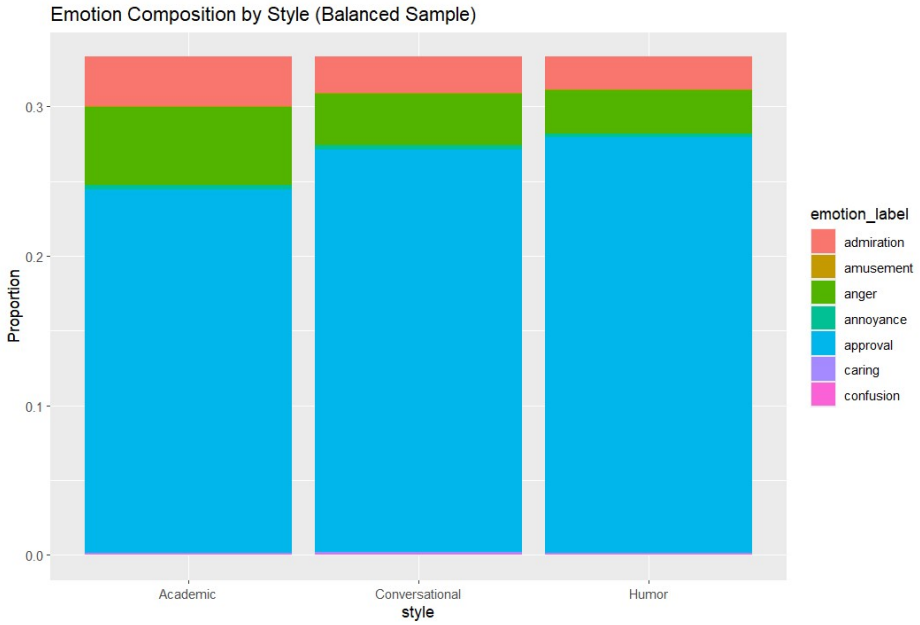

Figure 1. Emotion composition by style (balanced sample).

To further understand how styles influence user engagement on a cognitive level, we operationalized cognitive-emotion proxies through labels like confusion, admiration, and caring, and calculated their proportions by style. Figure 2 shows that humorous and conversational styles triggered slightly higher cognitive-related emotional responses than the academic style. This finding was counterintuitive, as traditional models of science communication often suggest that academic tone fosters deeper elaboration. However, the results from both the unbalanced and balanced samples demonstrated a consistent pattern: while academic style may invite credibility, it does not necessarily maximize cognitive-emotional activation compared to more accessible narratives.

To confirm whether the observed variations in cognitive-oriented emotional responses were statistically meaningful, a chi-square test of independence was conducted between communication style (humorous, conversational, academic) and emotion category (admiration, caring, confusion). The test was significant, $\chi^2(4) = 29.55$, $p < .001$, indicating that cognitive emotions varied systematically by style. Post-hoc pairwise comparisons with Bonferroni adjustment revealed that academic videos contained a significantly higher proportion of admiration and confusion than humorous or conversational styles ($p < .01$), while humorous content elicited relatively more caring responses. These findings confirm that the patterns illustrated in Figure 2 represent statistically reliable differences rather than descriptive variation. This aggregate analysis also confirms that communication style influences both emotional and cognitive forms of engagement, with humorous tone amplifying affective responses and academic style eliciting more cognitive ones.

Statistical testing using a chi-squared test on sentiment distribution also confirmed significant stylistic differences. The test produced a highly significant result ($\chi^2 = 457.97$, $df = 4$, $p < .001$), indicating that the relationship between narrative style and sentiment (positive, neutral, negative) was not due to chance, even after balancing the sample. While humorous videos remained dominant in positive sentiment, academic videos displayed a more polarized sentiment spectrum.

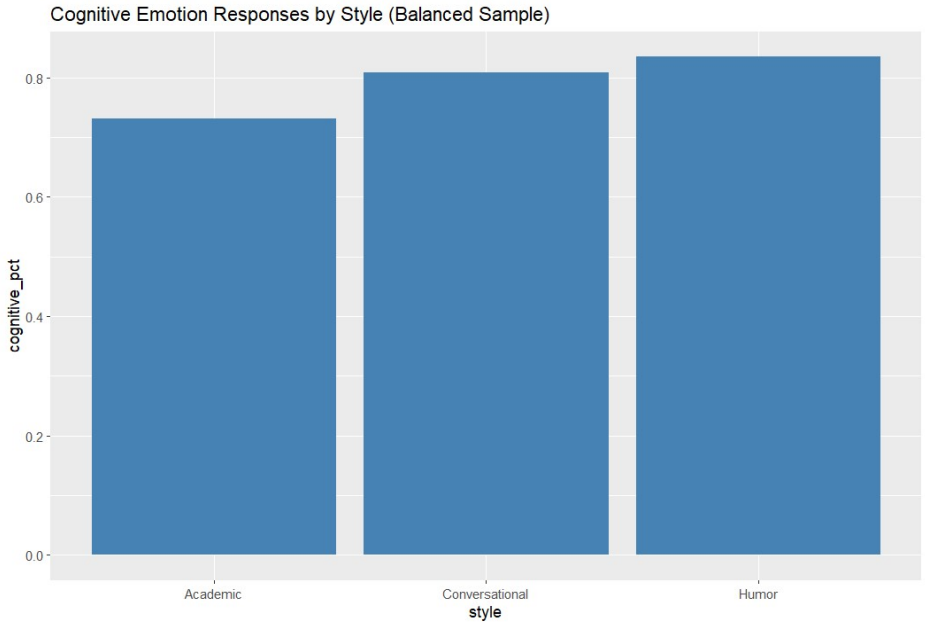

Figure 2. Proportion of cognitive-oriented emotional responses by style (balanced sample).

To test Hypothesis 1, that humor enhances positive emotional engagement but leads to lower cognitive elaboration compared to academic or conversational styles, we conducted both descriptive and inferential analyses using the balanced sample of user comments. Emotion distributions showed that humorous content was most effective at evoking positive affect, particularly approval and amusement, confirming the first part of the hypothesis (see Table 3). Also as illustrated in Figure 1, humor not only reduced the prevalence of anger and confusion but also dominated in expressions of social and affiliative sentiment.

Table 3. Distribution of key positive emotions by style (balanced sample).

Emotion Label	Academic	Conversational	Humorous
Approval	45,928 (60.9%)	48,441 (64.2%)	52,813 (70.0%)
Admiration	8,205 (10.9%)	7,844 (10.4%)	9,213 (12.2%)
Amusement	547 (0.7%)	698 (0.9%)	1,210 (1.6%)

However, the second part of the hypothesis was not supported. Contrary to the expectation that humor would suppress cognitive elaboration, the derived cognitive-emotion proxy analysis (confusion, admiration, caring) revealed that humorous videos exhibited a slightly higher proportion of such cognitively relevant responses compared to academic or conversational styles (Figure 2; Table 4). This suggests that humor may not simply simplify content but could facilitate more accessible pathways to cognitive engagement by reducing resistance or enhancing conceptual salience through surprise and metaphor.

To further probe this interaction, we fitted a multinomial logistic regression model with emotion labels as the outcome and style, focus, and topic as predictors. The model confirmed that humorous style significantly predicted higher likelihoods of positive emotions (approval, admiration), but did not predict a decrease in confusion, caring, or related markers of cognitive depth (Table 5). In fact, humorous style maintained a neutral to slightly positive

Table 4. Cognitive-oriented emotional proportions by style (balanced sample).

Emotion Proxy	Academic	Conversational	Humorous
Confusion	0.28%	0.31%	0.33%
Admiration	10.9%	10.4%	12.2%
Caring	0.18%	0.21%	0.23%
Cognitive Index (total)	11.36%	10.92%	12.76%

association with cognitive-emotional proxies, challenging the long-standing view that entertainment-based communication is antithetical to thoughtful engagement. The model specification includes both topic focus and style, thereby capturing the interaction between tone and content complexity. Results show that humor increases emotional engagement even in technically demanding topics.

Table 5. Multinomial logistic regression predicting emotion type by style and focus (balanced sample).

Emotion (vs. Approval)	Predictor	Coef.	SE	z / Sig.
Amusement	Intercept	-2.85	0.09	***
	Style: Conversational	-1.10	0.13	***
	Style: Humor	-0.44	0.06	***
	Focus: Mixed	-0.44	0.06	***
	Focus: Space Science	-1.30	0.13	***
Confusion	Intercept	-2.63	0.08	***
	Style: Conversational	-0.92	0.11	***
	Style: Humor	-0.28	0.05	**
	Focus: Mixed	-0.28	0.05	**
	Focus: Space Science	-1.44	0.12	***
Anger	Style: Humor	-0.00	0.01	ns
Caring	Style: Humor	-0.34	0.05	**

Note: Reference category is Approval. Significance codes: *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$, ns = not significant.

Table 6. Model fit and significance for multinomial logistic regression (emotion $\sim$ style $\times$ focus).

Model Metric	Value	df	p-value
Residual Deviance	86587.56	—	—
AIC	86635.56	—	—
Chi-square Test (style $\times$ sentiment)	457.97	4	$< .001$

Note: AIC = Akaike Information Criterion. Lower AIC indicates better model fit.

To assess the adequacy of the multinomial regression model, we examined overall model fit statistics. The model achieved a residual deviance of 86,587.56 and an AIC of 86,635.56, indicating acceptable fit given the complexity of the predictors (Table 6). Additionally, a separate chi-square test assessing the association between style and sentiment distribution yielded a highly significant result ($\chi^2 = 457.97$, $df = 4$, $p < .001$), confirming the robustness of the style-based effects observed in emotional engagement.

In summary, Hypothesis 1 is only partially confirmed. While humor strongly enhances positive affective responses, it does not detract from nor does it significantly suppress cognitive elaboration. These findings complicate the binary assumption that emotional appeal comes at the cost of intellectual depth, indicating that humorous science narratives can simultaneously entertain and cognitively stimulate.

Similar observations have been reported in other communication contexts, where humor encourages both emotional engagement and reflective processing. For example, Droog and Burgers [2024] show that certain forms of satirical news increase persuasive impact because they prompt audiences to recognize and interpret underlying contradictions. Their findings reinforce the interpretation that humorous formats do not necessarily weaken cognitive involvement but may instead create conditions that support deeper engagement.

To address Research Question 2, exploring which scientific topics in informal Arabic science videos are associated with user confusion and emotionally mixed reactions, we examined both the emotional distribution across topic clusters and the cognitive-emotional signature of thematically ambiguous content. The central aim was to identify clusters of content where emotional responses such as confusion, amusement, admiration, and anger were particularly prominent, indicating interpretative complexity or conceptual ambiguity. Using BERTopic, we extracted 183 distinct topic clusters from the dataset. From these, we filtered user responses that were tagged with a subset of emotions often indicative of cognitive conflict or dual-valence appraisal: confusion, amusement, admiration, and anger. These emotions collectively represented" mixed reactions," which we interpret as indicative of either informational overload, novelty, or unresolved moral or epistemic tension. After aggregating these responses by topic, we identified the top 10 science topics that elicited the highest volume of such emotionally complex responses (Figure 3).

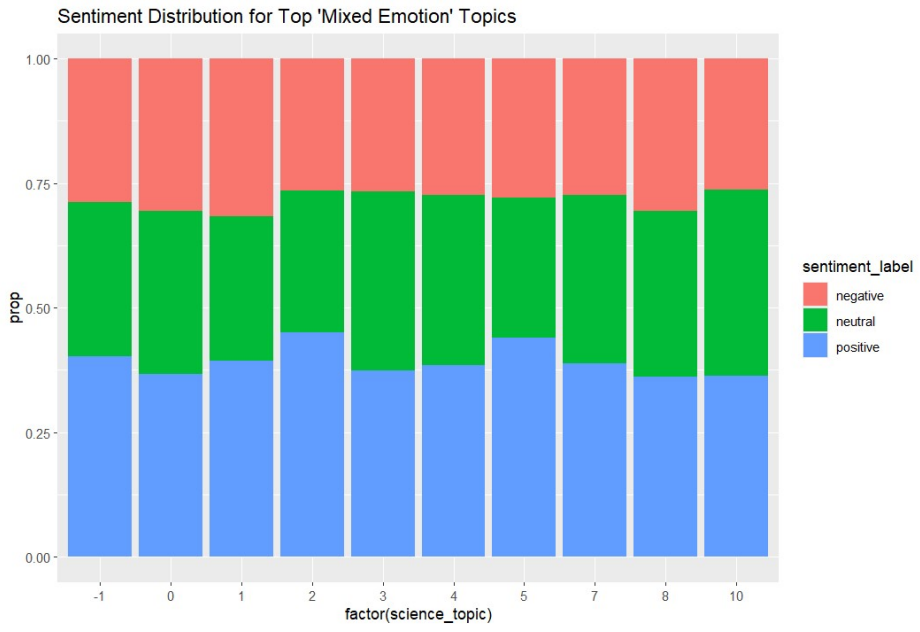

Figure 3. Top 10 science topics with the highest counts of confusion and mixed emotional responses.

The analysis revealed that topics involving cosmological theories, futuristic technologies, artificial intelligence, genetic engineering, and the interplay between science and religion

were most likely to prompt confusion and anger alongside admiration or amusement. These findings suggest that content which straddles abstract scientific inquiry and ethical speculation tends to activate more layered emotional responses. Such reactions may reflect both genuine curiosity and cognitive friction, often emerging when users encounter content that challenges prior knowledge, beliefs, or intuitive understanding.

To contextualize this further, we examined how these emotional patterns varied by the broader thematic focus of the videos — categorized as Medicine, Space Science, and Mixed Topics. Figure 4 illustrates that Space Science videos triggered a disproportionately high share of confusion and anger, while Medicine consistently evoked higher levels of approval and admiration. Mixed Topics displayed a wider spectrum of emotional engagement, likely due to their heterogeneity.

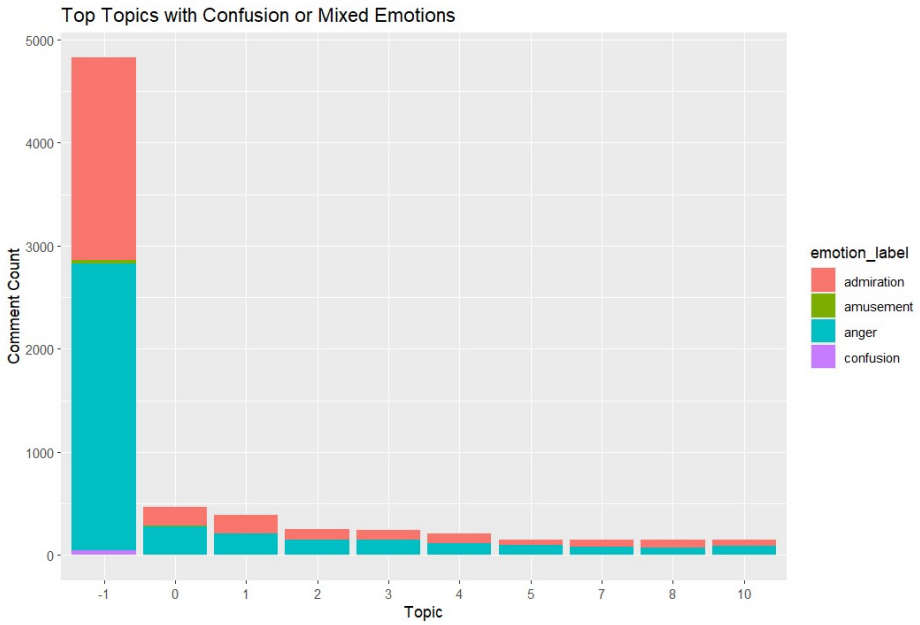

Figure 4. Emotion proportions by topical focus.

These patterns align with cognitive elaboration theories, which posit that emotionally ambiguous or uncertain content is not inherently disengaging; rather, it may signal increased mental effort and potential for epistemic growth. In particular, the frequent co-occurrence of confusion and admiration within the same topical clusters suggests that users are not simply rejecting difficult content but are engaging affectively with its complexity. This is further supported by multinomial logistic regression results, where science topic and focus were significant predictors of confusion-related responses, even after controlling for style. Taken together, the findings from Research Question 2 illustrate that user confusion is not uniformly distributed but concentrated in conceptually dense, controversial, or speculative domains. Importantly, this confusion coexists with emotions such as admiration and amusement, indicating interpretive openness rather than resistance. These results highlight the role of content type and scientific framing in modulating emotional complexity and underscore the need to approach confusion not merely as a breakdown in communication but as a marker of reflective engagement in informal science discourse.

These patterns align with the Elaboration Likelihood Model [Petty & Cacioppo, 1986] and Cognitive Elaboration Theory of Learning [D'Mello & Graesser, 2014], which propose that emotionally complex responses such as simultaneous confusion and admiration, enhance depth of processing. The findings further demonstrate that humor mitigates cognitive load in difficult topics, while conversational tone fosters empathy and academic style sustains perceived credibility.

5 ▪ Discussion

The findings of this study offer compelling insights into how Arabic-language science communication on YouTube elicits emotional and cognitive responses across diverse stylistic formats. Our results reinforce the evolving view in science communication literature that informal, entertainment-infused content is not only legitimate but often more effective in fostering engagement and emotional resonance, especially in linguistically and culturally distinct regions like the Arab world.

Historically, science communication operated under the assumptions of the deficit model, where public misunderstanding of science was attributed to a lack of knowledge [Bucchi, 1998; Schmid-Petri & Bürger, 2019]. However, this study aligns with the contemporary view that communication is a dialogic, culturally contextualized process [Gascoigne et al., 2020]. The dominance of positive affect, especially approval and amusement, in humorous science videos demonstrates that emotional appeal does not necessarily compromise cognitive engagement. These challenges assumptions embedded in older communication paradigms and add empirical weight to the argument that narrative and affective formats can coexist with, and even enhance, reflective engagement [Burns et al., 2003; Dahlstrom & Scheufele, 2018].

The emotion and sentiment results suggest that humorous videos not only evoke higher positive affect but also stimulate cognitive emotions such as admiration and caring. This contradicts conventional assumptions that entertainment necessarily leads to superficial processing [Scheufele, 2022]. Instead, the data suggest a dual effect of humor, whereby it reduces resistance to complex topics through affective engagement, while also enhancing cognitive elaboration via conceptual salience, surprise, and metaphorical framing [Yeo et al., 2020, 2021].

Interestingly, the emotional variance across video styles also reinforces the notion of differentiated audience pathways. The humorous style appears to facilitate accessibility, conversational style encourages relatability, and academic style preserves credibility. However, the academic style alone did not significantly elevate cognitive-oriented emotions. This suggests that while expertise and formal tone may communicate authority, they may not be sufficient to foster emotional or reflective engagement among wider publics. These findings resonate with research by Augenstein [2021] and Humm et al. [2020], which emphasize the importance of balancing credibility with affective accessibility in digital environments.

The study also reveals topic-specific effects. Videos dealing with abstract, futuristic, or ethically charged topics such as artificial intelligence, cosmology, or genetic engineering elicited elevated levels of confusion, anger, and admiration. This emotional complexity supports theories of cognitive elaboration and dual processing, where emotionally mixed

responses reflect deeper engagement rather than simple misunderstanding [Dahlstrom & Scheufele, 2018; Nisbet & Scheufele, 2009]. The co-occurrence of admiration and confusion especially suggests that users may be engaging thoughtfully with difficult or novel ideas, rather than dismissing them outright. This resonates with Kulczycki [2013], who noted that digital platforms like YouTube create spaces for negotiated meaning-making where users can express both epistemic uncertainty and curiosity.

The emotional complexity surrounding certain scientific topics also indicates that not all confusion is problematic. Indeed, within the context of informal science learning, confusion can signal a transition point toward conceptual change [D'Mello & Graesser, 2014]. From this perspective, confusion becomes a pedagogically valuable emotional state, particularly when accompanied by admiration or interest. Hence, emotional ambiguity in user responses should not be interpreted merely as failure of communication, but as evidence of affective-cognitive engagement. Our findings thus challenge science communicators to rethink the role of emotions like confusion and anger in public engagement, especially on digital platforms.

Equally significant are the cross-style comparisons on cognitive-emotion proxies. The fact that humorous videos triggered higher proportions of cognitive-emotional responses than academic ones invite rethinking of science communication pedagogy. Rather than promoting academic style as the default standard, educators and communicators might consider humor and narrative not as embellishments but as tools of epistemic utility. This aligns with contemporary calls for transmedia, multimodal, and participatory approaches in science engagement [Bucchi & Trench, 2021].

Another key insight from the multinomial regression is the resilience of the humorous style in preserving cognitive-emotional engagement, even after controlling for topic and focus. These further challenges simplistic dichotomies between emotional and rational appeals, and supports the notion of edutainment as a viable model of informal science learning [Jucan & Jucan, 2014]. These findings are particularly relevant in Arabic contexts where educational hierarchies and traditional didactic norms may limit engagement. Humor may thus offer a culturally sensitive entry point for science communication by softening authoritative boundaries and enabling dialogic spaces.

Moreover, the results support the idea that audience emotional responses are shaped not only by content but also by delivery, tone, and perceived intention. Videos using humor or storytelling not only humanize science but also facilitate the social bonding necessary for trust-building [Navalhas, 2025]. In a region like the Middle East and North Africa (MENA), where trust in institutional science can be uneven, these affective bridges are crucial.

The emotional resonance of humorous content also intersects with issues of inclusion and access. Prior studies suggest that emotional exclusion and perceived elitism are barriers to science engagement among marginalized communities [Archer et al., 2015; Judd & McKinnon, 2021]. The capacity of humorous, relatable formats to foster emotional inclusion highlights the need for more diversified and culturally attuned communicative strategies.

Theoretically, this study contributes to the growing body of literature that calls for a synthesis between cognitive and emotional models of science communication. It validates the AEIOU framework by demonstrating how enjoyment and approval do not negate cognitive responses but can actively facilitate them. It also engages with models of participatory science

communication by showing how users not only receive content but actively reflect and react in affectively complex ways.

Practically, the study encourages science communicators and content creators to leverage humor and storytelling not just for audience retention but as instruments for deeper public engagement.

Methodologically, this study showcases the potential of combining emotion detection with transformer-based models in Arabic, a linguistically under-resourced language. The use of cognitive-emotion proxies and topic-emotion mapping further expands the repertoire of tools available for computational science communication research. The dataset and code can serve as a reference for future analyses seeking to explore cultural dynamics in digital science engagement.

6 ▪ Limitations

This study offers a focused analysis of audience responses to Arabic informal science communication on YouTube but has limitations. First, analyzing only three channels, @Da7ee7, @NidhalG, and @Espitalia, limits generalizability across the broader Arab digital space. Although chosen for their stylistic diversity, they may not reflect the range of formats and dynamics on other platforms like Instagram or X. Future research could explore how platform-specific features, such as algorithms and content formats, shape engagement and emotional response.

Second, each communication style is represented by a single channel (e.g., @Da7ee7 for entertainment, @NidhalG for academic, @Espitalia for medical-conversational), reflecting purposive sampling rather than statistical representativeness. Therefore, the findings are illustrative rather than generalizable to all Arabic science communication. The selected channels serve as paradigmatic cases, but future work should include multiple examples per style to disentangle stylistic from channel-specific effects.

Finally, while computational sentiment and emotion analysis enables scalable insight, it may miss contextual nuance. Qualitative methods like interviews or focus groups could complement this approach. Further studies may also explore stylistic variables e.g., visuals, presenter identity or pursue cross-cultural comparisons to broaden understanding of digital science communication.

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1. During the preparation of this work, the authors used ChatGPT (OpenAI) for editing services to enhance readability and language clarity. After using this service, the authors carefully reviewed, and finalized all content. The authors assume full responsibility for the content of the published article. The authors affirm their commitment to transparency and ethical scholarship in line with the publisher's guidelines by disclosing the limited and assistive use of AI tools.

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