Interactional Metadiscourse in Popular Science: A Comparative Analysis across Subgenres and Pedagogical Implications

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Abstract

The increasing availability of scientific knowledge through digital platforms has transformed how scientific discourse reaches the general public. This study examined the use of interactional metadiscourse markers across four leading popular science subgenres: books, TV documentaries, magazine articles, and newspaper articles. The aim was to investigate the language features of these markers, focusing on how they engage readers and highlight writer presence in different subgenres. A corpus of 987,625 words was analyzed using AntConc software (Anthony, 2019) and 80,260 instances of interactional markers were identified according to Hyland's (2019) Interpersonal Model of Metadiscourse. The study revealed how hedges, boosters, attitude markers, self-mentions, and engagement markers function to create persuasive and accessible content. Interestingly, interactional markers appeared most frequently in TV documentaries, suggesting a heightened effort to engage audiences through this medium. Chi-square tests revealed significant differences in marker usage across subgenres; however, the small effect sizes (Cramér's V) indicated that these differences are of only modest practical significance. These results provided insight into how popular science writers adapt their rhetorical strategies to suit different communicative contexts and audience expectations. The findings also have pedagogical implications. Incorporating features of popular science into ESP/EAP materials, such as authentic texts and structured practice with interactional metadiscourse markers, can make scientific content more engaging and accessible for learners. Raising learners' awareness of interactional metadiscourse markers can improve writing skills, especially for novice writers in non-English academic settings, helping them better engage readers and communicate more effectively.

Keywords: ESP and EAP Materials, Interactional Metadiscourse Markers, Language Characteristics, Popular Science Subgenres, Reader Engagement

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INTRODUCTION

The rapid advancement of scientific discoveries, alongside the need to process and disseminate vast amounts of information, requires popular science writers (or popularizers) to understand their audience to achieve social and rhetorical goals. Popular science serves as a bridge between the scientific community and the general public, communicating breakthroughs to non-specialist audiences via online news, podcasts, documentaries, and books (Egorova, 2018; Hyland, 2009). In the digital age, its growing accessibility increases public engagement, helping close the gap between experts and laypeople by providing clear, relatable content (Wu & Qiu, 2012). Popularizers act as intermediaries, transforming complex information into engaging narratives that resonate with everyday experiences (Belas, 2014; Moirand et al., 2016). To capture wide interest, they often emphasize discoveries with global significance and humanize scientists to make science more approachable (Parkinson & Adendorff, 2004). Yet, science popularization is not without challenges. It must present findings as provisional, manage technical terminology carefully, and maintain both theoretical coherence and rhetorical persuasiveness. This includes using accessible metaphors that allow readers to engage critically with the content, even when it simplifies or recontextualizes scientific language (Pilkington, 2019; Belas, 2014).

In light of this, the use of metadiscourse markers can be seen as an effective way to address these challenges. The role of popular science in educating a general audience is akin to planting seeds of knowledge. Popularizers play a crucial role in nurturing these seeds, enriching them with metadiscourse elements that structure and clarify the content for readers. Vande Kopple(1985) explains that texts operate on two levels: the propositional level, where information is presented, and the metadiscourse level, which helps readers interpret and evaluate that information. Essentially, metadiscourse is communication about communication, enhancing understanding without adding new content. It serves as a writer's commentary

that guides readers, helping them grasp the intended meaning. Metadiscourse shapes content to improve comprehension and engagement, reflecting the writer's stance and awareness of the audience. By organizing material for clarity and persuasion, it allows writers to project their presence into the text, making it more accessible and compelling for readers (Hyland & Jiang, 2022; Hyland, 2019).

Writers use metadiscourse to address objections, express viewpoints, and engage readers, managing interactional meaning effectively (Hyland, 2019). According to Hyland's (2019) interpersonal model, metadiscourse is categorized into interactive and interactional markers. Interactive markers help organize content to suit readers' knowledge and interests, structuring the discourse to enhance understanding. In contrast, interactional markers are more personal, reflecting the writer's stance and actively engaging readers by fostering solidarity, anticipating objections, and encouraging participation. These markers are keys to conveying a writer's perspective and building audience connection, serving persuasive, informative, or engaging purposes (Chen & Li, 2023; Hyland & Jiang, 2022). Interactional markers are particularly vital in communicating scientific advancements to non-expert audiences (Hyland, 2019). This importance prompted us to center our research on these markers. They guide readers through complex material by addressing reader expectations, refining communication, and responding to potential objections. In popular science, interactional metadiscourse balances the need to highlight the significance of scientific claims while avoiding exaggeration. By using these markers, writers emphasize their claims' uniqueness, engage readers, and express emotional responses, making the content more accessible and compelling. Several scholars (Almakrob, 2023; Chen & Li, 2023; Fu & Hyland, 2014; Liu & Zhang, 2022) have highlighted the importance of interactional metadiscourse markers in popularized materials, emphasizing their role in both engaging audiences and enhancing public understanding of the concepts. These markers help clarify implicit knowledge claims, making complex information more accessible to general readers. Despite their significance, limited research has examined the

characteristics of interactional markers across different popular science subgenres, particularly regarding their similarities, differences, and usage patterns.

Inexperienced writers often struggle with using these markers effectively, as they may not fully understand how essential these tools are for improving reader engagement and ensuring clarity in scientific communication. This knowledge gap can make it difficult for them to anticipate where readers might need further explanation or assistance in interpreting the concepts. Additionally, there is an unresolved question about how interactional markers influence audiences' perceptions and guide their attention within popular science content. Without a clear understanding of how and where to apply these markers, writers risk creating content that is harder to comprehend and less engaging for their audience. This study, therefore, aims to explore how variations in interactional metadiscourse markers (hedges, boosters, attitude markers, self-mentions, and engagement markers) impact communication effectiveness across different subgenres of popular science discourse: Books, TV documentaries, magazine articles, and newspaper articles. These four subgenres were selected because they reflect diverse rhetorical environments and audience engagement strategies. Books offer extended narratives and deeper cognitive engagement; TV documentaries rely on visual and auditory modes to build emotional resonance and enhance accessibility; magazines typically blend entertainment and information, using attractive layouts and a conversational tone to appeal to general readers; and newspaper articles prioritize brevity, immediacy, and clarity to inform audiences quickly. Examining these varied formats enables a comprehensive analysis of how interactional markers are deployed across different platforms, each shaped by its communicative purpose, production constraints, and audience expectations.

LITERATURE REVIEW

Popular science makes abstract scientific concepts accessible by simplifying complex ideas and linking them to readers' prior knowledge, all while

considering societal implications (Hyland, 2009, 2010; Hudoshnyk & Krupskyi, 2022; Wu & Qiu, 2012). This approach thrives on three core factors: interest, simplicity, and authentic scientific representation. First, popular science sparks curiosity by challenging widely accepted beliefs, aiming more to engage than strictly to educate (Pilkington, 2019). Second, simplicity is central, with writers employing metaphors, analogies, and minimal jargon to make scientific claims understandable and relatable (Hyland, 2009; López Orellana, 2012). Finally, rather than emphasizing technical evidence, popular science highlights new and intriguing ideas in an accessible format, blending authenticity with entertainment to engage lay audiences (Babaii et al., 2017; Bucchi & Trench, 2014). Pilkington (2016) argues that popular science fosters public connection with scientific concepts through engagement strategies, emphasizing implicit understanding over explicit knowledge. This shift enables the audience to connect emotionally with science, interpreting concepts meaningfully rather than contributing directly to knowledge production. Consequently, popular science redefines public-scientist relations by encouraging deeper, emancipatory comprehension.

In recent years, scholars like Myers (2003) and Pilkington (2016, 2019) have shown significant interest in the role of linguistic elements in popularizing scientific concepts. López Orellana (2012) and Hudoshnyk and Krupskyi (2022) explored interactive mechanisms that enhance reader engagement. Additionally, Pilkington (2019) and Limnios (2023) examined the use of scientific terminology in popular science texts, highlighting strategies for presenting clear and engaging language. Furthermore, Bellés-Fortuño (2016) and Hyland (2010) compared discourse features between popular science texts and scientific articles, offering valuable insights into their differences.

Metadiscourse enriches scientific writing by reflecting the author's presence, allowing scientists to communicate more personally beyond presenting facts. This adaptation enhances the effectiveness of scientific discourse, meeting specific communication needs and structuring

professional activities. It reveals a complementary relationship between scientists' beliefs and the cognitive frameworks guiding scientific genres, rather than causing conflict (López Orellana, 2012). Generally, metadiscourse provides a framework for understanding how language influences a reader's perception of content (Hyland, 2019). Numerous studies have explored the use of metadiscourse markers across a range of genres. For example, they have been investigated in hotel responses to negative reviews (Zhou & Li, 2023), medical letters (Yang, 2021), academic contexts (Babaii et al., 2016; Rababah et al., 2024; Sarani & Talati-Baghsiahi, 2017), public instruction manuals (Herriman, 2022), and abstracts from various academic disciplines (Ruonan & Al-Shaibani, 2022). These studies emphasize metadiscourse as a rhetorical strategy that shapes discourse organization and demonstrates genre-specific ways in which writers engage their readers. Additionally, in their study, Firdaus and Shartika (2021) compared metadiscourse use in scientific versus popular science texts, highlighting how differing conventions of knowledge construction correspond to particular linguistic strategies and rhetorical positioning.

A significant body of research has also examined interactional metadiscourse in both scientific and popularized discourse. Hyland and Jiang (2020) note that interactive and interactional metadiscourse elements overlap, both contributing to the interpersonal dynamics of a text. Interactional features, showing the writer's presence through attitudes, commitments, and evaluations, help writers engage readers and achieve communication goals, thereby blurring traditional boundaries between these metadiscourse types within scientific discourse. Fu and Hyland (2014) analyzed the variation of these markers across genres, particularly in persuasive writing, while Kuhi and Babapour (2019) explored hedges and boosters in professional and popular science discourse to show how they mediate writer-reader relationships. Scholars including Chen and Li (2023), Lai (2023), and Zhou and Li (2023) have expanded this inquiry to news commentaries and popular science writing. Meanwhile, other researchers (e.g., Almakrob, 2023; Esfandiari & Allaf-Akbary, 2024; Liu & Deng, 2024; Liu & Zhang, 2022)

have investigated interactional metadiscourse within academic genres using Hyland's (2005) framework, identifying genre-based patterns in the distribution and functions of these markers.

The Present Study

Guided by Hyland's (2019) interpersonal model, this study addresses a critical gap in existing research, which has mainly explored the general features and effectiveness of popular science communication, but it has not examined the specific linguistic elements that enhance audience engagement across various subgenres. Although previous studies have focused on the role of interactional metadiscourse, they have largely done so outside the context of popular science, neglecting how these markers influence audience preferences within different subgenres. This study aims to fill this gap by analyzing interactional markers across popular science materials, which represents a novel approach in the field. Specifically, it examines the similarities, differences, and impacts of these markers in subgenres such as popular science books, TV documentaries, magazine articles, and newspaper articles.

For the first time, this research investigates how the writer's presence and the use of interactional markers affect audience engagement, shedding light on what makes popular science appealing and accessible. The study also aims to explain how these linguistic elements contribute to the success of popular science across various formats. The research will address the following questions:

1. What are the primary interactional metadiscourse markers employed by popular science writers?
2. Do popular science subgenres differ significantly in their use of interactional metadiscourse markers?

METHOD

Design of the Study

This study employed a mixed-method approach, combining quantitative and qualitative analyses. In the quantitative phase, the distribution of interactional markers was examined across four popular science subgenres: Books, TV documentaries, magazine articles, and newspaper articles. Beyond measuring frequencies, the study also compared the relative proportions and usage patterns of each marker type across subgenres to identify significant differences in rhetorical strategies. In the qualitative phase, Hyland's (2019) model was used to analyze and compare the similarities and differences in the use of these markers, providing an in-depth examination of how interactional resources are utilized in popular science content.

Data Collection

The corpus for this study consists of four distinct sub-corpora, each representing a variety of popular science materials, to facilitate a comprehensive analysis of interactional metadiscourse across different subgenres. It includes transcriptions of 150 popular science TV documentaries (359,722 words) produced between 2015 and 2024. All transcripts were checked against the original videos to ensure accuracy. The corpus also includes 150 magazine articles (184,623 words) published between 2018 and 2024; 150 newspaper articles (162,202 words) published between 2015 and 2024; and 60 chapters from 30 popular science books (281,094 words) published between 2013 and 2024.

The selection of materials was guided by several key criteria. The primary goal was to ensure thematic diversity, covering a broad range of science-related topics. Subjects included geology, anatomy, biology, neurology, nutrition, ecology, technology, climate change, and COVID-19, with each item chosen for its relevance to these themes. Another crucial criterion was the credibility and accessibility of the sources. Materials were

gathered from reputable platforms known for their accuracy in disseminating scientific content. Books were obtained from *Z-lib.org, pdfbooksworld.com,* and *sciencebooksonline.info*. TV documentaries were transcribed from *BBC Earth, National Geographic,* and *NOVA on YouTube*. Magazine articles were taken from *Sciencenews, Scitechdaily, National Geographic, Popsci, Wired, Cosmosmagazine,* and *Neurosciencenews,* while newspaper articles were obtained from *The New York Times, The Guardian, Sky News, The Los Angeles Times, The Washington Post, BBC,* and *The Daily Mail*. All sources were chosen for their reliability and adherence to strict editorial standards, ensuring the integrity of the data (all materials were originally in English). The selected time frame, 2013 to 2024, was intended to capture recent scientific discussions and developments. With a total of 987,625 words, the corpus provides a robust foundation for analyzing interactional metadiscourse markers across different popular science subgenres, offering both breadth and depth to the study's examination of popular science discourse (see Table 1).

Table 1: Overall description of the corpus

Subgenres	Sources	Sample size	Year	Number of words
Books	Z-lib.org, pdfbooksworld.com, sciencebooksonline.info	60 chapters	2013-2024	281,094
TV documentaries	BBC Earth, National Geographic, NOVA on YouTube	150 documentaries	2015-2024	359,722
Magazine Articles	Sciencenews, Scitechdaily, Nationalgeographic, Popsci, Cosmosmagazine, Neurosciencenews Wired	150 articles	2018-2024	184,623
Newspaper Articles	Nytimes, Theguardian, News.sky, Latimes, Washingtonpost, BBC, Dailymail	150 articles	2015-2024	162,202

Analytical Framework

Hyland's (2019) classification of interactional metadiscourse was adopted with its five distinct subcategories (see Table 2).

Table 2: Hyland's (2019) classification of interactional metadiscourse

Category	Function	Examples
Hedges	Show uncertainty, allowing audience interpretation	about, could, may
Boosters	Emphasize certainty, reinforcing arguments	find, actually
Attitude Markers	Express writer's attitudes or stance	amazing, interesting
Self-Mentions	Refer to the writer, personalizing discourse	I, we, my
Engagement Markers	Address the audience to maintain engagement	look at, consider

In contrast, **interactive metadiscourse** is concerned with organizing and guiding the reader through the structure of the content. Writers use linguistic tools to help readers follow the argument or narrative, such as *first*, *for example*. These markers aid in organizing information, clarifying relationships between ideas, and managing the flow of the discourse with transitions like *thus*, *however*. The primary aim of interactive metadiscourse is to improve coherence and enhance comprehension by structuring the content effectively (Hyland, 2019).

Data Analysis

This study aimed to investigate the use of interactional metadiscourse markers across various popular science subgenres such as books, TV documentaries, magazine articles, and newspaper articles, using a structured, multi-step methodology. First, materials were randomly selected from major websites representing each subgenre (as listed in Table 1) to create distinct sub-corpora. The Antconc 3.5.7 software (Anthony, 2019) was then used to analyze the frequency of interactional markers based on Hyland's (2019) classification. Descriptive statistics were applied to compare marker usage across subgenres, with results expressed in raw numbers (N) and normalized frequencies (NF) per 10,000 words. To examine whether differences in marker use across subgenres were statistically significant, Chi-square tests were conducted using IBM-SPSS 27.0. This non-parametric test was selected due to the categorical nature of the data. In addition to significance values (p),

effect sizes were calculated using Cramér's V to assess the practical significance of the observed differences.   Lastly, a qualitative analysis was conducted to explore the similarities, differences, and communicative functions of the interactional markers in context. This involved close reading of representative excerpts from each subgenre, guided by Hyland's (2019) functional categories. Markers were analyzed in their immediate textual environment to determine how they contribute to stance-taking, audience engagement, or rhetorical positioning. Recurring functions and patterns were then grouped into themes through inductive coding, allowing for cross-subgenre comparison and interpretive depth.

RESULTS and DISCUSSION

Quantitative Analysis: The major interactional markers used in popular science content

The first research question examines the primary interactional metadiscourse markers used by popular science writers. Table 3 provides a detailed analysis of the different interactional metadiscourse features employed, along with chi-square test results and effect sizes (Cramér's V) for each category to determine both statistical and practical significance. The data reveal a total of 80,260 instances of interactional metadiscourse markers within the analyzed corpus. The chi-square test showed significant variation in the use of these markers across the four subgenres ($X^2 = 309.769$, $p < .001$), indicating distinct usage patterns in each.

According to the data, interactional markers were most frequently found in TV documentaries (NF = 1,085.9), followed by books (NF = 729.3), magazine articles (NF = 614.5), and least frequently in newspaper articles (NF = 576.9), all normalized per 10,000 words. As seen in Table 3, engagement markers were the most common, with 32,133 occurrences (40.02%), followed by self-mentions at 18,750 instances (23.35%), and hedges at 15,271 occurrences (19.03%). Boosters appeared 10,630 times (13.26%), and attitude markers were the least frequent, with 3,485 instances

(4.35%). Cramér's V values indicate that while the chi-square tests show statistically significant differences, the effect sizes are generally small (ranging from V = 0.037 to 0.099). This suggests that although subgenres differ in their use of interactional markers, the practical magnitude of these differences is modest. Such small effect sizes are not uncommon in corpus-based linguistic studies, where large samples often yield statistically significant but subtly differentiated patterns.

Table 3: The distribution of Interactional markers

Interactional markers	Books		TV docs		Magazine articles		Newspaper articles		Total N	Percentage	x^2	sig.	Cramér's V
	N	NF	N	NF	N	NF	N	NF					
Hedges	4,570	162.6	5,131	142.7	2,917	157.9	2,653	163.6	15,271	19.03%	251.46	<.001	0.091
Boosters	2,620	93.2	4,940	137.3	1,626	88.1	1,444	89.1	10,630	13.26%	202.2	<.001	0.084
Attitude markers	1,119	39.8	1,218	33.9	621	33.7	527	32.5	3,485	4.35%	55.682	<.0011	0.043
Self-mentions	3,485	123.9	12,249	340.6	1,608	87.1	1,408	86.9	18,750	23.35%	42.451	<.001	0.037
Engagement markers	8,705	309.7	15,521	431.5	4,582	248.2	3,325	204.9	32,133	40.02%	144.086	<.001	0.076
Total	20,499	729.3	39,059	1,085.9	11,345	614.5	9,357	576.9	80,269	100%	309.769	<.001	0.099

Note. N= raw frequency; NF = normalized frequency per 10,000 words.

The findings show that popularizers across subgenres consistently rely on interactional metadiscourse markers, particularly engagement and self-mention features, as key rhetorical strategies. This shared pattern reflects a common goal of personalizing discourse, building rapport with readers, and making scientific content more accessible. At the same time, the distribution of these markers reveals subtle variations across subgenres. Although the chi-square tests indicate statistically significant differences in usage, the effect sizes suggest that these differences are relatively small in practical terms. This means that while writers follow broadly similar strategies, they also adjust their use of metadiscourse to suit the specific communicative context and audience of each subgenre.

Qualitative Analysis: Variations in interactional markers usage among popular science subgenres

The second research question explored the differences in the use of interactional markers across various popular science subgenres. Table 3 provides a detailed comparison, highlighting notable variations in the use of interactional markers across all four subgenres and offering insight into the distinct linguistic strategies employed in each.

Hedges:

The findings indicate that hedging markers are the third most common interactional subcategory, accounting for 19.03% of the total. They are most frequently used in newspaper articles (NF = 163.6), followed closely by books (NF = 162.6) and magazine articles (NF = 157.9), and are least common in TV documentaries (NF = 142.7). The chi-square test (X^2 = 251.46, p < .001) confirms a significant variation in the use of hedging markers across the subgenres.

Table 4: The most frequent hedges

Books			TV docs			Magazine articles			Newspaper articles		
Type	*N*	*NF*	*Type*	*N*	*NF*	*Type*	*N*	*NF*	*Type*	*N*	*NF*
about	582	20.8	about	1039	28.9	about	440	23.9	could	412	25.5
would	425	15.2	would	664	18.5	could	372	20.2	about	384	23.7
may	399	14.2	could	580	16.2	may	300	16.3	would	282	17.4
could	335	11.9	around	454	12.7	would	246	13.4	may	219	13.6
should	202	7.2	may	206	5.8	might	157	8.6	around	161	9.9
might	201	7.2	might	193	5.4	around	157	8.6	likely	107	6.6
often	163	5.8	should	173	4.9	likely	97	5.3	might	93	5.8
around	163	5.8	almost	171	4.8	should	87	4.8	often	69	4.3
rather x	136	4.9	feel	157	4.4	often	85	4.7	should	69	4.3
possible	127	4.6	maybe	143	3.9	possible	83	4.5	possible	60	3.7

Note. N= raw frequency; NF = normalized frequency per 10,000 words

As shown in Table 4, markers such as *about, would, may, could, should, might, often*, and *around* are commonly used across all subgenres. Consistent with prior research (Fu & Hyland, 2014; Sanosi & Mohammed, 2024; Zhou & Li, 2023), the hedges in this corpus include various types of interactional

metadiscourse serving functions like moderation, accommodation, and mitigation. These hedges allow writers to acknowledge diverse viewpoints while avoiding full commitment to scientific claims, thus conveying a more subjective perspective (Hyland, 2019). To enhance acceptance among readers, writers often use mediating markers, such as epistemic modal verbs (*might*, *may*), adverbs (*often*, *around*, *rather*), and epistemic verbs like *feel*, typically combined with assumptions, definitions, or descriptions of scientific results. Furthermore, authors may emphasize key subjects of the experiments, such as scientists, doctors, or researchers, as illustrated in Excerpt 1.

> (1) *However, in the early twentieth century **scientists** discovered that they **couldn't** calculate what **would** happen over short distances.(Penguin Press)*

Through these markers, writers express their perspectives without asserting absolute certainty, cautiously presenting their knowledge claims. They acknowledge that the results may vary in other experiments or may be specific to the given experimental context. Other common markers, such as epistemic adjectives (*possible*, *likely*) and modal verbs (*may*, *could*, *maybe*), serve as tools to temper scientific assertions. These interactional markers help writers to present arguments with careful negotiation, allowing them to introduce concepts as tentative, feasible, and open to interpretation. In other words, these linguistic devices are used to justify the generalizability, expected or unexpected outcomes, probability, plausibility, and assumptions of scientific claims, see Excerpt 2.

> (2) N*ewts in Northern California are **likely** to suffer the same consequences in coming years.(Wired)*

As demonstrated in Excerpts 1 and 2, these linguistic tools help audiences evaluate claims by offering a platform for critique, making the claims more accessible. To achieve this, authors must create room for

multiple interpretations and allow for critiques of their findings. Mitigating markers such as *about, would, could, might, almost* and *should* along with epistemic verbs or adverbs like *suggest, seems, consider, think, expect, feel, consider* or *perhaps* serve to moderate the strength of assertions. This is particularly important when the knowledge claims challenge established ideas, as these markers indicate that the claims are not merely personal opinions but are rooted in scientific experimentation (see Excerpt 3).

(3) ***Perhaps**, like a comic book superhero, the humble neutrino saved us from annihilation.(BBC News)*

Additionally, these markers indicate that the authors have taken into account the possibility of conflicting evidence and the likelihood of audience disagreement, which may result in criticism of the assumptions presented (Chen & Li, 2023; Fu & Hyland, 2014). In general, the use of hedging markers enables popularizers to build a sense of connection with their readers while recognizing the potential limitations and uncertainties inherent in scientific knowledge.

Boosters:

Boosters represent the fourth-most common subcategory, accounting for 13.26% of all interactional markers across the four sub-corpora. They are most frequently used in TV documentaries (NF = 137.3) and books (NF = 93.2), followed by newspaper articles (NF = 89.1), with magazine articles using the fewest boosters (NF = 88.1) compared to the other subgenres. The chi-square test ($X^2 = 202.2$, $p < .001$) reveals significant differences in the use of boosters across subgenres. The relatively lower frequency of boosters in magazine articles may be attributed to the editorial style and communicative goals typical of this subgenre. Popular science magazines often aim to maintain a tone of neutrality and balance, appealing to a broad readership that values informative rather than persuasive content. As a result, writers may

intentionally avoid emphatic or assertive language that could be perceived as biased or overly authoritative.

Table 5: The most frequent boosters

Books			TV docs			Magazine articles			Newspaper articles		
Type	*N*	*NF*	*Type*	*N*	*NF*	*Type*	*N*	*NF*	*Type*	*N*	*NF*
Know	225	8.1	know	853	23.8	found	226	12.3	found	289	17.9
Must	168	5.9	really	716	19.9	known	121	6.6	known	130	8.1
Found	168	5.9	think	658	18.3	know	112	6.1	find	85	5.3
Shows	136	4.9	actually	357	9.9	really	103	5.6	really	84	5.3
Known	122	4.4	find	254	7.1	think	102	5.6	know	80	4.9
think	116	4.2	never	231	6.5	actually	77	4.2	think	69	4.3
show	112	3.9	found	184	5.2	find	71	3.9	show	62	3.9
find	112	3.9	thought	178	4.9	shows	56	3.1	shows	55	3.4
always	110	3.8	believe	154	4.3	certain	50	2.8	never	52	3.2
never	104	3.6	always	138	3.9	thought	49	2.8	thought	46	2.9

Note. N= raw frequency; NF = normalized frequency per 10,000 words

Table 5 shows that four markers like *know*, *found*, *think*, and *find* are shared across all sub-corpora. In line with previous studies (Liu & Zhang, 2022; Qiu et al., 2023; Rababah et al., 2024), the boosting markers identified in this analysis help shape the writers' tone, convey authority and confidence when presenting scientific information to a broad audience, and assert the certainty of scientific principles (Hyland, 2019). Markers such as *find*, *show*, *found* and *thought* are particularly used to provide strong, objective evidence and emphasize certainty. To effectively communicate precise scientific results to non-expert audiences with varying perspectives, writers use boosters to strengthen their arguments, offer convincing evidence, and present claims in a way that resonates with the audience's understanding (Rababah et al., 2024). This approach helps establish credibility through the inherent strength of the assertions themselves. Additionally, adjectives and adverbs like *certain*, *really*, *actually* and *always* are powerful tools for intensifying the definitiveness of scientific developments (Excerpt 4).

> (4) *What remains **uncertain** is what was inside these early hand grenades.(Mail Online)*

By using such boosters, authors can maintain an objective stance when presenting information, reinforcing their judgments while avoiding any subjective bias in making definitive claims. Convincer markers such as *know*, *known*, *shows*, *show*, *really*, *certain*, *actually*, *find*, *found*, and *never* are strategically selected to engage the audience, appeal to their prior knowledge, and create a sense of shared pursuit in scientific progress. These markers are particularly effective in mediating scientific knowledge to non-experts who lack specialized understanding in the field. The mediation process relies on specific linguistic tools, such as hedging and boosters, allowing popularizers to present scientific information through their perspective (Excerpt 5).

(5) *The width of the tooth root is twice as large as any* ***known*** *aquatic reptile. (Cosmos)*

Boosters such as *believe*, *must be*, *think*, *thought*, *find*, *found* and *know* play a key role in helping popularizers effectively convey the importance of new or ongoing scientific experiments to their audiences. These terms are strategically used to signal the need for revisions or updates to previous research findings (Excerpt 6).

(6) *Researchers* ***found*** *that placing a few stickers on a stop sign can lead software to interpret the sign.(Science News)*

These terms suggest that further exploration and investigation are crucial for uncovering potential solutions for new problems that may arise due to evolving circumstances (Almakrob, 2023). Therefore, the use of boosting techniques emphasizes the need for new research to address gaps and challenges in current scientific literature, enriching the field with fresh insights and innovative solutions.

Attitude markers:

In this study, attitude markers represent the least frequent subcategory of interactional metadiscourse (4.35%). They are most commonly found in books (NF = 39.8), followed by TV documentaries (NF = 33.9), magazine articles (NF = 33.7), and newspaper articles, where they are used the least (NF = 32.5). The chi-square test revealed a significant difference in the use of attitude markers across the subgenres ($X^2 = 55.682$, $p < 0.011$).

Table 6: The most frequent attitude markers

Books			TV docs			Magazine articles			Newspaper articles		
Type	*N*	*N F*	*Type*	*N*	*N F*	*Type*	*N*	*N F*	*Type*	*N*	*N F*
even x	423	15.1	even x	477	13.3	even x	221	11.9	even x	143	8.9
Important	196	6.9	important	135	3.8	important	106	5.8	important	73	4.6
(Exclamation marker)!	69	2.5	amazing	109	3.1	expected	26	1.5	(Exclamation marker)!	63	3.9
essential	48	1.8	interesting	70	1.9	(Exclamation marker)!	21	1.2	expected	51	3.2
curious	33	1.2	remarkable	40	1.2	essentially	19	1	agreed	18	1.2
appropriate	27	0.9	dramatic	35	0.9	surprising	18	0.9	essential	17	1
interesting	24	0.8	unusual	26	0.8	interesting	17	0.9	surprised	15	0.9
surprising	24	0.8	essentially	22	0.7	unusual	17	0.9	interesting	11	0.7
agree	16	0.6	surprising	22	0.7	surprised	15	0.8	surprising	10	0.7
agreed	15	0.6	unfortunately	22	0.7	essential	14	0.8	dramatic	10	0.7

Note. N= raw frequency; NF = normalized frequency per 10,000 words

As shown in Table 6, four attitude markers like *surprising*, *interesting*, *important* and *even x* (used for contrast or emphasis to highlight surprising or noteworthy information), and (*exclamation markers*) *!* (used to create urgency or emotional intensity, especially in magazine articles to grab attention and dramatize findings) are the most frequently observed and shared across all

four sub-corpora. Consistent with previous studies (Chen & Li, 2023; Chou et al., 2023; Lai, 2023), the attitude markers in this corpus encompass various interactional types, reflecting the writers' emotional or evaluative stance. These markers are particularly crucial when engaging a lay audience, as they help authors express enthusiasm, appreciation, interest, or curiosity about scientific discoveries (Hyland, 2019). For instance, content estimators like *appropriate* or *dramatic* are often used to convey opinions or approval, creating excitement or intensity around research methodologies or findings (Excerpt 7). Additionally, markers such as *important*, *curious*, *remarkable*, *essential*, and *essentially* serve as effective tools to emphasize the value and relevance of scientific information for a general audience (Excerpt 8). These markers help simplify the core goal of popularizing science, bridging the gap between scientific reporting and a broad readership, while persuasively highlighting the importance of the discoveries.

(7) *It seems that said scientists viewed the magazines as an **appropriate** place to publish.(Transcript Verlag)*
(8) ***Importantly**, aphasia is not a disease, but rather a symptom of brain damage.(Cosmos)*

Popularizers deliberately employ commendatory markers such as *amazing* or *interesting* to spark curiosity and captivate audiences with solid scientific findings, while also fostering a sense of familiarity. This intentional approach enhances the accessibility and clarity of scientific claims (Lai, 2023) and generates excitement and enthusiasm among readers (Excerpt 9). Similarly, other markers like *agree* or *unfortunately* are used to convey the writers' personal views and emotional responses to the scientific concepts presented (Excerpt 10).

(9) *That helped avoid wasting time driving to **unexceptional** rocks that had looked potentially **interesting** in images taken from orbit.(Science News)*

(10) *Experts **agree** that a quintuple jump might be the most spins that the sport can dream for.(Popular Science)*

In Excerpts 7 to 10, the writer strategically uses attitude markers to emphasize how the results either contradict initial assumptions or align with anticipated outcomes (including markers like *expected*). This approach allows the author to offer personal insights on scientific discoveries while drawing the audience's attention to the surprising or predictable nature of the findings.

Self-mentions:

The results indicate that self-mention markers are the second most frequent subcategory of interactional metadiscourse, accounting for 23.35% of the total. TV documentaries show a significantly higher use of self-mentions (NF = 340.6) compared to books (NF = 123.9), newspaper articles (NF = 87.1), and magazine articles, which closely follow (NF = 86.9). The chi-square test ($X^2 = 42.451$, $p < .001$) confirms a significant variation in the use of self-mention markers across the subgenres. The analysis revealed that out of a predetermined list of 11 subcategories, 8 specific types of self-mentions were consistently found in all four subgenres (see Table 6).

Table 7: Entire self-mention markers

Books			TV docs			Magazine articles			Newspaper articles		
Type	N	NF	Type	N	NF	Type	N	NF	Type	N	NF
I	790	20.8	I	4,299	119.5	I	334	18.1	I	322	19.9
We	1,418	50.5	We	4,536	126.1	we	725	39.3	we	547	33.8
Me	117	4.2	Me	629	17.5	me	55	3	me	46	2.9
My	201	7.2	My	835	23.3	my	46	2.5	my	91	5.7
Our	547	19.5	Our	1,212	33.7	our	266	14.5	our	248	15.3
Mine	4	0.2	Mine	16	0.5	mine	9	0.5	mine	7	0.8
Us	396	14.1	Us	720	20.1	us	164	8.9	us	142	8.8
the author	10	0.4	the author	1	0.03	the author	8	0.5	the author	5	0.4
the author's	–	–	the author's	–	–	the author's	–	–	the author's	–	–
the writer	2	0.08	the writer	1	0.03	the writer	1	0.06	the writer	–	–
the writer's	–	–	the writer's	–	–	the writer's	–	–	the writer's	–	–

Note. N= raw frequency; NF = normalized frequency per 10,000 words

Table 7 shows that markers like *I, we, me, my, our, mine, us,* and *the author* are shared across all four sub-corpora. The use of these markers enables writers to convey their stance and assert their identity (Hyland, 2019), particularly when combined with other subcategories. For instance, self-mentions are often paired with hedges to present conservative knowledge claims. Specifically, the modulation of self-mentions, such as those listed in Table 6, or referring to key subjects in the experiments like *scientists*, *doctors*, or *researchers* alongside attitude markers or hedges helps soften the authority of rigid scientific findings. This is crucial as overly assertive or absolute scientific claims can lead readers to view them with skepticism, perceiving them as exaggerated or biased (Excerpt 11).

> (11) *Finally—and this is the **important** one—**you could** just drive slower.(Wired)*

Another approach involves combining boosters and self-mentions like *I*, *we*, *us*, or *our* with evidentials to create more assertive and compelling arguments (Excerpt 12). This strategy aligns with the findings of Fu and Hyland (2014) and Lai (2023).

> (12) ***I'm** going to make one graph to **show** what **would** happen if things get bad and gas prices reach 11.40 per gallon. For this plot, **I'm** going to **assume** a pay rate of 20 dollars per hour. (Science News)*

This combination not only enhances the credibility of the arguments but also strengthens the author's connection to the ongoing discourse, showcasing their active involvement (Chen & Li, 2023). Moreover, it reflects the popularizers' strong commitment and accountability as contributors to scientific knowledge.

Engagement markers:

The findings of this study, consistent with previous research (Fu & Hyland, 2014; Yang, 2021), reveal that engagement markers are the most frequently used subcategory of interactional metadiscourse, accounting for 40.02% of the total. These markers are most prevalent in TV documentaries (NF = 431.5), followed by books (NF = 309.7), magazine articles (NF = 248.2), and newspaper articles (NF = 204.9), where they appear least often. The use of engagement markers also varied significantly, with a chi-square value (X^2 = 144.086, $p < .001$).

Table 8: The most frequent engagement markers

Books			TV docs			Magazine articles			Newspaper articles		
Type	N	NF	Type	N	NF	Type	N	NF	Type	N	NF
Parenthesis (..)	1,863	66.3	we	4,536	126.1	we	725	39.3	we	547	33.8
We	1,418	50.5	you	4,024	111.9	Parenthesis (..)	663	35.9	Parenthesis (..)	406	25.1
You	559	21.4	our	1,212	33.7	you	534	28.9	you	327	20.2
Our	547	19.5	see	863	23.3	your	284	15.4	our	248	15.3
Question?	433	15.5	us	720	20.1	Question?	276	14.9	Question?	193	11.9
us	396	14.1	go	599	16.7	our	266	14.5	use	154	9.5
your	362	12.9	your	552	15.4	use	169	9.2	us	142	8.8
see	274	9.8	have to	291	8.1	us	164	8.9	your	136	8.4
use	269	9.6	find	254	7.1	see	143	7.8	see	103	6.4
should	202	7.2	look at	200	5.6	should	87	4.8	find	85	5.3

Note. N= raw frequency; NF = normalized frequency per 10,000 words

As shown in Table 8, six engagement markers such as *see, your, us, we, you,* and *our* are shared across all four sub-corpora. *Parentheses (...)* also appeared frequently (used to provide clarifications, definitions, or cite sources, particularly in books where additional scientific explanations are embedded within the main text). Consistent with previous studies (Almakrob, 2023;

Esfandiari & Allaf-Akbary, 2024; Liu & Deng, 2024), the engagement markers in this corpus reflect a range of interactional elements that personify the audience and use directives to foster participation and involvement. These markers help guide the audience through key points, anticipate potential questions, and immerse them in the experience of discovering scientific facts (Hyland, 2019). Based on Table 8, other prominent terms are *we, you, our, us* and *your*. These markers act as signals between writers and audiences, highlighting the intended recipients of the message. For example, in Excerpt 13, popularizers deliberately employ these markers to build solidarity and inclusivity with a lay audience, helping them grasp and connect with the practical implications of complex scientific research. Similarly, in Excerpt 14, the use of the second-person pronoun *you* and *your* encourages the audience to see themselves as active participants in scientific achievements, engaging both emotionally and intellectually (Fu & Hyland, 2014).

> (13) ***We*** already ***find*** *fungi such as Penicillium, transported by man* ***himself*** *or other vectors that were not there before.(Springer)*
> (14) *When* ***you*** *are connected to* ***your*** *environment,* ***you*** *know best how to approach it.(Science News)*

The identified directives include imperatives like *see, use, go, find*, and *look at* which effectively guide readers through the content. These markers encourage readers to engage actively by prompting specific actions (Hyland & Jiang, 2022). Such imperatives direct the audience's focus to key information or specific sections of the text. Meanwhile, obligators like *should* or *have to* urge readers to accept certain claims or draw mental conclusions. Popularizers directly address the audience using *we* and other self-references to capture attention. They often combine *we* with boosters like *know*, *must*, or *find* to navigate the audience through the material (Excerpt 15). This deliberate use of self-references establishes a sense of connection, inclusivity, and engagement within the ongoing discourse (Chen & Li, 2023).

(15) *It reads the microchip 'so **we know** which individual got the seeds and what they did with them' he said.(The New York Times)*

Engagement markers allow authors to share personal insights, often enclosed in parentheses or dashes, providing clarification and expanding on preceding statements. They enhance coherence by introducing supplementary scientific details and offering deeper insights into principles, reasoning, and formulas (Excerpt 16). Rhetorical questions engage audiences by stimulating thought and encouraging critical reflection. Writers use them to draw readers into the discussion, introduce topics, and grab attention. By reinforcing arguments with implied examples and prompting deeper reflection, rhetorical questions promote active involvement with the subject matter (Excerpt 17).

(16) *During which life might have appeared, either spontaneously or through panspermia **(that is, brought from somewhere else in the universe).**(Penguin Random House)*
(17) ***Could three seconds a day of resistance exercise really increase muscular strength?***

Overall, the use of inclusive interactional metadiscourse serves the key purpose of engaging diverse audiences in various aspects of scientific research. Writers employ this approach to involve readers in logical reasoning, often alongside hedges (Liu & Deng, 2024; Yang, 2021). These linguistic features enable authors to present their viewpoints, reinforced by boosters. By incorporating inclusive strategies, writers can effectively guide readers to their intended interpretations of the research findings.

CONCLUSION

This study, grounded in Hyland's (2019) interpersonal model, examined the distribution and rhetorical function of interactional metadiscourse markers across four popular science subgenres. The findings reveal that popularizers

use these markers strategically to achieve communicative goals, foster engagement, and establish a dialogic relationship with non-specialist audiences. Through corpus-based distributional and functional analyses, the study demonstrates significant variations in marker usage across subgenres, reflecting the distinct communicative strategies tailored to each medium. These strategies align with the narrative-driven nature of popular science, which aims to make complex scientific concepts accessible, persuasive, and relevant to a general readership (Pilkington, 2019).

Hedging markers were frequently found in newspaper articles and books. In newspapers, they helped simplify complex ideas while maintaining precision and acknowledging uncertainty. In books, they functioned to balance authority with openness to alternative interpretations, particularly in extended discussions. This rhetorical moderation contributed to the credibility and accessibility of scientific content across subgenres. Boosters were most prevalent in TV documentaries and books, where they reinforced the certainty of claims and maintained audience interest. Attitude markers, though the least used, were more common in books and documentaries. These markers allowed authors to express emotional or evaluative stance, such as enthusiasm or urgency, thereby deepening audience engagement. Self-mentions were used most frequently in books and TV documentaries to personalize the discourse and position the narrator as a credible guide. In contrast, their use was limited in newspapers and magazines, where a more neutral tone is often preferred. Engagement markers emerged as the most widely used interactional resources, especially in books and documentaries. These markers guided audiences through arguments, encouraged reflection, and established inclusive, reader-oriented communication.

The findings also underscore the pivotal role of genre conventions in shaping science communication. Each subgenre exhibits distinct rhetorical norms that influence how scientific content is structured, how the writer's stance is conveyed, and how audience interactions are managed. For instance, the narrative elaboration and authorial visibility found in books facilitate extended engagement and support a wider range of interactional markers. In

contrast, TV documentaries, shaped by time constraints and multimodal presentation, employ more emphatic strategies, such as boosters and engagement markers, to capture attention quickly. Newspaper articles, prioritizing brevity and immediacy, often reduce the use of self-mentions or hedges in favor of concise, declarative statements. Magazine articles, often situated between the narrative depth of books and the brevity of newspapers, strike a balance by employing both evaluative language and explanatory scaffolding to appeal to curious but time-conscious readers. These conventions guide not only the form and delivery of information but also how credibility, stance, and reader alignment are achieved. Recognizing these genre-based rhetorical expectations is crucial for writers, educators, and material developers seeking to promote effective science communication.

The study's findings offer several pedagogical implications. Incorporating features of popular science into ESP and EAP instruction can help bridge the gap between expert and general discourse, making scientific language more accessible and engaging. Using authentic texts from popular science genres exposes learners to real-world rhetorical practices and supports the development of genre awareness and scientific literacy. Additionally, training learners to recognize and use interactional metadiscourse markers can enhance their rhetorical competence, particularly in crafting persuasive and coherent academic texts. This is especially beneficial for novice writers and second-language users, who often struggle with audience awareness and stance management in academic communication. Nevertheless, a key limitation of this study is its exclusive focus on textual analysis without incorporating audience reception data. Future research could address this gap by examining how readers or viewers actually interpret and respond to interactional metadiscourse strategies across various subgenres. Such work could provide deeper insights into the effectiveness of these rhetorical choices and further inform pedagogy and genre-based writing instruction.

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