Research Article

A Comparative Analysis of Interactive Metadiscourse across Popular Science Commentaries: Magazine Articles and Newspaper Articles

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Abstract

Drawing on established metadiscourse frameworks, this study examined the use of interactive metadiscourse markers in popular science commentaries across various topics. The analysis was based on a balanced corpus of 300 magazine and newspaper articles published between 2015 and 2024, a period marked by increased public interest in scientific issues. Using AntConc software as a corpus analysis tool, the study identified patterns in the use of interactive markers and compared their distribution across the two subgenres. The findings revealed that these markers were used frequently, with magazine articles showing a more systematically organized presentation of content. Chi-square tests demonstrated significant differences between the two corpora in the distribution of transitions, endophoric markers, evidentials, and code glosses. These results have important pedagogical implications for ESP and EAP, offering valuable insights for curriculum developers, instructors, and other stakeholders on effective strategies for teaching rhetorical competence. Increasing students' awareness of interactive metadiscourse can improve textual coherence, enhance reader comprehension, and support both novice and experienced academic writers. Furthermore, educators can develop practical classroom activities to help learners identify and improve these aspects in their writing.

Keywords: corpus analysis, ESP/EAP resources, interactive metadiscourse, popular science commentaries, rhetorical strategies

Introduction

Popularization of science is a tool for communicating scientific discoveries to the general audience, regardless of their level of expertise in the field, through diverse mass media platforms such as radio podcasts, online news, television documentaries, popular science magazines, newspaper articles, books, and weblogs (Hyland, 2009). Its accessibility, applicability, and practicability make a connection between inner scientific spheres, like academic elites from across the scientific spectrum, and the outer sphere, such as experts or non-experts that need virtues of popular science texts (Wu & Qiu, 2012). The significant of popular science in educating lay audience is comparable to the planting of seeds of knowledge. Popular science writers (popularizers) play a vital role in tending to these seeds, imbuing them with empowering metadiscourse elements that organize the structure of the content conveyed to the readers.

Metadiscourse functions as a form of commentary that guides readers, builds logical connections, and encourages engagement. It demonstrates how readers interpret meaning, follow the writer's stance, and connect with arguments (Hyland & Jiang, 2022). As a rhetorical strategy, it helps shape content presentation based on anticipated reader comprehension. Specifically, interactive metadiscourse markers assist in organizing content around the reader's knowledge, interests, and interpretive expectations (Hyland, 2019). Popular science, as a key component of scientific discourse, is often described as a hybrid form of communication. It is collaboratively developed with a strong focus on engaging readers in social and interpersonal meaning-making. At the same time, it functions as a unified channel for transmitting knowledge (Kuhi, 2017). Science popularization involves re-contextualizing and reformulating source materials to make them accessible and relevant to lay audiences. This process includes rephrasing and reframing scientific claims using specific linguistic choices to effectively engage the target audience (Hudoshnyk & Krupskyi, 2022). In transferring meaning between professional and popular science genres, interactive features are "central to these translations of meanings across genres" (Hyland, 2019, p. 114). This distinctive feature of popular science commentaries suggests that investigating interactive metadiscourse within them would provide valuable insights into how popularizers create an unfolding, cohesive, persuasive, and reader-friendly piece of writing.

Numerous studies have explored metadiscourse marker use across diverse genres, including secondary-level English learner texts (Chung et al., 2023), instruction manuals (Herriman, 2022), hard-science research articles (Wei & Duan, 2019), hotel responses to negative reviews (Zhou & Li, 2023), and newspaper editorials by native and non-native writers (Kuhi & Mojood, 2014) and so on. These investigations demonstrate how metadiscourse devices shape discourse flow according to genre conventions, aligning linguistic choices with knowledge-construction practices to enhance textual cohesion.

Further research has examined interactive metadiscourse across varied academic contexts. Hyland and Jiang (2020) tracked the evolution of reader-focused, text-organizing markers in leading journals across four disciplines over fifty years, finding a clear shift toward reader-oriented writing. Lee and Park (2023) identified similar trends in English-teaching research articles by Korean scholars since 1980. Tessuto (2021) analyzed interactive metadiscourse in open-access economics and law articles, while Alqahtani and Abdelhalim (2020) studied its use in EFL students' academic essays. Kashiha and Marandi (2019) compared metadiscourse in introductory sections of applied linguistics and chemistry papers. Subsequent investigations by Memon et al. (2021), Pasaribu et al. (2022), Khedri and Basirat (2022), and Alghazo et al. (2023) have reinforced these findings. Adapting Hyland's (2005, 2019) model, these studies, have demonstrated how genre norms influence writers' selections of interactive metadiscourse markers, highlighting significance differences or similarities in their distribution across different corpora.

Popular science materials often focus on abstract concepts, scientific

discoveries, and the timely reporting of novel developments. Researchers in the fields of social sciences and communication examine how scientific knowledge is popularized. This includes the simplification, explanation, and dissemination of complex ideas for general audiences. This process relies on language features that connect new information with readers' existing knowledge, while also addressing broader social and political contexts (Fu & Hyland, 2014; Hyland, 2009, 2010; Pilkington, 2016; Wu & Qiu, 2012). In discourse analysis, scholars such as Pilkington (2016, 2019) and Orellana (2012) have explored how cohesion and interactive strategies contribute to reader engagement. Pilkington's (2019) study of terminology in popular science texts reveals how clarified definitions and reader-friendly language enhance comprehension. Additionally, several researchers have compared discourse features in popular science and academic articles (e.g., Bhatia, 2013; Hyland, 2010), offering insights into how genre conventions shape the presentation and interpretation of scientific content.

Among these, Fu and Hyland (2014) examined how interactional metadiscourse markers differ across genres and influence persuasive writing, emphasizing how writers establish their presence by engaging with both content and audience. Their study used a large corpus of popular science articles from *Scientific American*, *American Scientist*, *New Scientist*, and *Science Magazine*, alongside opinion pieces from *The Guardian*, *Telegraph*, *LA Times*, and *NY Times*. Similarly, Kuhi and Babapour (2019) investigated hedges and boosters in popular and professional science texts, showing how interactional markers foster interpersonal engagement and support persuasive aims. Egorova (2018) and Ruonan and Al-Shaibani (2022) argued that interactive features not only enhance engagement but also help lay audiences interpret scientific content by embedding implicit knowledge cues. Despite these contributions, only a limited number of studies have explored interactive or interactional metadiscourse in scientific contexts such as, medical writing (e.g., Chen & Li, 2023; Nugrahani & Bram, 2020), popularized media (e.g., Yin, 2022), social media (e.g., Huang et al., 2023), and social science publications (e.g., Ruonan & Al-Shaibani, 2022).

Although previous studies have explored metadiscourse across a variety of genres, they have largely overlooked how interactive metadiscourse markers function in popular science communication, particularly in comparing different subgenres. Existing research has tended to emphasize academic texts or interactional features, leaving a gap in our understanding of how interactive markers help structure content and guide comprehension for lay audiences.

This study seeks to address this gap by conducting a comparative analysis of interactive metadiscourse markers in two major subgenres of popular science commentaries: magazine articles and newspaper articles, both of which play a critical role in disseminating scientific knowledge to the general public. These resources were selected for their prominence and accessibility, as well as their influence on public understanding of science. By examining how interactive markers are distributed and function across these subgenres, the study aims to uncover the rhetorical strategies used

by writers to organize content, manage reader engagement, and enhance textual coherence. In doing so, this research not only addresses an underexplored area in metadiscourse studies but also offers new insights into the strategic linguistic choices that shape popular science writing for non-specialist audiences. Accordingly, it aims to answer the following questions:

RQ1: What are the distributional differences of interactive metadiscourse markers in popular science magazine articles and newspaper articles?

RQ2: What are the similarities and differences in the utilization of interactive metadiscourse between popular science magazine articles and popular science newspaper articles?

Analytical framework

The term metadiscourse, introduced by Zellig Harris in 1959, refers to a writer's or speaker's efforts to shape the audience's understanding of content (Hyland, 2019). In the 1980s, scholars broadened the concept to include textual features that influence how messages are received, thereby enhancing engagement and comprehension. According to Vande Kopple (1985), discourse operates on two levels: propositional content conveys information, while metadiscourse helps readers organize, interpret, and evaluate that content. In this sense, metadiscourse is communication about communication.

According to Vande Kopple (2012), metadiscourse is important for several reasons. It reveals the structural complexity of language and can be studied across texts from various disciplines and languages. Metadiscourse markers significantly influence communication by aiding interpretation and elaboration of texts. Hyland and Tse (2004) highlight metadiscourse as linguistic tools that allow writers to structure texts, engage readers, and express stance and perspective simultaneously. Later, Hyland (2019) refined this concept into a comprehensive framework, which this study adopts. He categorizes metadiscourse into two main types: interactional and interactive markers. Interactional markers are inherently personal, expressing the writer's stance and attitude while involving the reader in the discourse. These are "evaluative and engaging, expressing solidarity, anticipating objections and responding to an imagined dialogue with others" (Hyland, 2019, p. 58). In contrast, interactive markers are used to shape the reader's understanding by organizing content in line with audience needs and expectations. As Hyland (2019) explains, these markers reflect awareness of the reader's "probable knowledge, interests, rhetorical expectations, and processing abilities" (p. 57). According to his model, interactive markers are divided into five subcategories: transition markers, frame markers, endophoric markers, evidentials, and code glosses (see Table 1).

These components are not only the means to engage reader the in a dialogue with the writers but are also function as breadcrumbs guiding readers through the text. By linking content, providing explanations, indicating text progression, and referencing other parts of the text, they serve a purpose beyond mere structural cohesion. They are both cohesive and practical, as they reflect the writer's internal conversation with the reader and demonstrating the writer's judgment on how best to

convey information in a clear and persuasive manner tailored to specific readers (Hyland & Jiang, 2020). Therefore, the intrinsic importance of interactive markers in framing scientific developments for lay audiences (Hyland, 2019) cannot be overstated.

This research focuses on interactive metadiscourse markers due to their relevance in analyzing popularized scientific writing. It aims to compare how popularizers use these markers as rhetorical tools to guide readers' inferences and direct attention. As this category helps integrate readers' prior knowledge with scientific developments, making content accessible and supporting comprehension (Memon et al., 2021), it is valuable to examine how writers emphasize these features to meet structural and audience expectations. Table 1 outlines the five subcategories of interactive metadiscourse from Hyland's (2019) model, including definitions and examples. This framework guides our comparison of marker use in popular science magazine and newspaper articles.

Table 1
A Model of Interactive Metadiscourse (Hyland, 2019)

Subcategory	Function	Examples
Transitions	Express connections between steps within arguments	Furthermore, but
Frame markers	Mark schematic structure, sequences, steps, arguments	Then, next
Endophoric markers	Direct to other sections of the content	Refer to the next section, as noted above
Evidentials	Illustrate the source of knowledge claims	According to X, X states
Code glosses	Help readers grasp and recover the producers' intended meaning	Called, for example

Corpus and method

Data collection

This study adopted a corpus-based methodology supported by a comparative-descriptive quantitative approach. The corpus consisted of 300 popular science commentaries, comprising 150 magazine articles and 150 newspaper articles published between 2015 and 2024. These texts covered a broad range of scientific topics, including geology, anatomy, biology, neurology, nutrition, ecology, media studies, technology, climate change, and COVID-19, ensuring both topical diversity and relevance to contemporary public discourse.

To ensure the sample reflected genre-representative and high-impact publications, sources were selected based on three key criteria. First, each publication

featured a dedicated science or technology section to guarantee thematic relevance. Second, each source reached a large and diverse readership, capturing content aimed at both general audiences and subject-matter enthusiasts. Third, each publication was recognized for its editorial quality, frequent citation in science communication research, and consistent publication of accurate and accessible science reporting.

Based on these criteria, magazine articles were selected from *Science News*, *SciTechDaily*, *National Geographic*, *Popular Science*, *Wired*, *Cosmos*, and *Neuroscience News*. Newspaper articles were drawn from *The New York Times*, *The Guardian*, *Los Angeles Times*, *BBC News*, *News Sky*, *The Washington Post*, and *Daily Mail*. The selection process was grounded in explicit and measurable standards, including topical focus, audience reach, and editorial credibility. Accordingly, a balanced and representative corpus was constructed to support the analysis of interactive metadiscourse markers across popular science subgenres. An overview of the corpus is presented in Table 2.

Data analysis procedure

The purpose of the current study was to explore the use of interactive metadiscourse markers across two popular science commentaries: magazine articles and newspaper articles. To fulfill this goal, after collecting the texts, two corpora were compiled. Each corpus consisted of 150 popular science articles randomly selected from the official websites listed in Table 2. The corpus of magazine articles comprised 184,623 words, and the selected newspaper articles were converted into a corpus of 162,202 words. Each subgenre's average article word count is about 1,230 and 1,082 words, respectively. Overall, the larger the size of the corpora, the more real instances of the target markers can be seen in flowing discourse, which strengthens the reliability of the data. This exact procedure guaranteed that the collected data were representative of a broad spectrum of popular science writings.

Following that, the Antconc 3.5.8 concordance software (Anthony, 2004), renowned for its capacity to analyze text corpora, was employed for estimating the frequency of interactive metadiscourse based on Hyland's (2019) classification within each corpus. In this regard, every instance was thoroughly examined to verify its role as interactive markers. This process aided in the identifying of the most frequently used interactive markers in each corpus, enabling a systematic and unbiased analysis.

Then, a statistical analysis was conducted to calculate the distribution features of interactive metadiscourse across both subgenres. This quantitative investigation permitted a comparison of the frequency of usage among numerous interactive markers. Considering the difference in corpus size, the results were reported in both raw numbers (N) and normalized frequency (NF) per 10,000 words. This approach accurately depicts the proportional prevalence of various interactive markers across corpora. Subsequently, a chi-square test was performed using IBM-SPSS 27.0 to reveal significant differences between the two corpora.

Further analysis of the most frequent interactive metadiscourse markers in magazine and newspaper articles was conducted to identify similarities, differences, and functions across the corpus. Examples were extracted and interpreted to show how

rhetorical resources operate as interactive devices within sentences. This approach reflects Hyland's (2019) emphasis on contextual meaning over dictionary-based definitions. The combination of statistical analysis and contextual interpretation enhanced understanding of marker use in popular science writing. Applying a triangulated analysis further broadened the study's scope and strengthened the identification of cross-subgenre patterns. Table 2 illustrates the overall description of the corpus.

Table 2

Overall Description of the Corpus

Genres	Sources	Numbers	Words	Year
Magazine Articles	Sciencenews, Scitechdaily, Nationalgeographic, Popsci, Cosmosmagazine, Neurosciencenews Wired	150	184,623	2015-2024
Newspaper Articles	Nytimes, The Guardian, News.sky, Latimes, Washington post, BBC, Dailymail, Los Angeles Times	150	162,202	2015-2024

Results and Discussion

RQ1: The distribution of interactive metadiscourse subcategories

The first research question of the study investigates how writers use interactive metadiscourse markers in popular science magazine articles and newspaper articles, while also identifying similarities and differences within both popular science commentaries. Table 3 presents an analysis of the usage of the interactive metadiscourse subcategories in the collected datasets. This quantitative analysis indicates that both subgenres employed such markers. This highlights that interactive metadiscourse serves as an important linguistic resource for maintaining text cohesion and enhancing content clarity. This aligns with the findings of Hyland and Jiang (2020) and Tessuto (2021), who assert that writers often employ such resources in both research and publications.

Significant differences in the occurrences of transition markers, endoporic markers, evidentials, and code glosses were observed, as illustrated in Table 3 below. The results of chi-square test are $X^2= 137.752$, P= $0.000 < 0.05$, $X^2= 9.523$, P= $0.002 < 0.05$, $X^2= 4.068$, P= $0.043 < 0.05$ respectively, and $X^2= 29.163$, P= $0.000 < 0.05$. This suggests that significant statistical differences between the two corpora are specifically evident in the use of these four subcategories of interactive metadiscourse.

This study found no statistical difference in the use of frame markers between the magazine articles and newspaper articles corpora, X2= 0.402, P= 0.526 (Table 3). In other words, writers of both popular science magazine articles and newspaper articles employ frame markers, which are nearly equally distributed in both corpora, to delineate boundaries between different parts of the content.

Table 3

Distribution of interactive metadiscourse features in both popular science subgenres

Interactive markers	Magazine articles			Newspaper articles			chi square test	
	N	% of total	NF	N	% of total	NF	x^2	P-value
Transitions markers	7,197	54.7	389.9	5,856	51.6	361.1	137.75	0.000
Frame markers	1,968	14.9	106.6	2,008	17.7	123.8	0.402	0.526
Endophoric markers	578	4.4	31.3	431	3.8	26.5	9.523	0.002
Evidentials	237	1.8	12.9	283	2.5	17.5	4.068	0.043
Code glosses	3,167	24.2	171.5	2,767	24.4	170.6	29.163	0.000
Total	13,147	100	712.1	11,345	100	699.5	180.908	0.571

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

Furthermore, transition markers emerge as the most prevalently used subcategory of interactive metadiscourse in magazine articles as indicated by the rate frequency of instances in both corpora in Table 3. They constitute 54.7% of the employed interactive metadiscourse markers. Likewise, transition markers in newspaper articles ranked the first place and account for 51.6% of the five subcategories of interactive metadiscourse. Therefore, it can be reasonably claimed that writers of magazine articles, compared to newspaper article writers, tend to manage the flow of discourse in a similar manner. This could be attributed to keen focus of popularizers on stressing the interactive aspects of the content, which potentially improves the readability and comprehensibility.

It is also noteworthy that evidentials were rarely found in the corpus of magazine articles, accounting for only 1.8% (Table 3) of the total number of interactive metadiscourse, which is slightly less than the 2.5% observed in newspaper articles. This might reflect popularizers' reluctance to explicitly acknowledge the inclusion of the resources in popularized content. As suggested by Alqahtani and Abdelhalim (2020), the minimal use of evidentials can be explained by the nature of the genre, where writers do not feel a pressing necessity to support their arguments.

As illustrated in Table 3, in the corpus of newspaper articles, code glosses were the second most frequent feature of interactive markers, accounting for 24.4% among the five subcategories. The occurrences of code glosses in the newspaper articles are 170.6 per 10,000 words, 2,767 items in total, which is just as frequent as those in the magazine articles, accounting for 24.2% with 171.5 per 10,000 words and 3,167 items in total. The results suggest that this may be seen as a reflection of stronger intention among popularizers to elaborate on scientific claims with appropriate clarification. Frame markers in the newspaper articles account for 17.7% with 123.8 per 10,000

words and a total of 2,008 items, making them the third most frequent interactive feature. Being at the same rank but less frequent, such markers in the magazine articles occupy 14.9% of all interactive subcategories with 106.6 per 10,000 words and a total of 1,968 items. Additionally, the frequency of endophoric markers in the magazine articles was marginally higher than those used in the newspaper articles, accounting for 4.4% with 31.3 per 10,000 words and 578 items, compared to 3.8% with 26.5 per 10,000 words and 431items in total.

In general, the occurrences of interactive metadiscourse subcategories indicate that frame markers, evidentials, and code glosses in the newspaper articles are more prevalent than those in the magazine articles. However, the total number of interactive metadiscourse markers (Table 3) was higher in the magazine articles with 13,147 total items (712.1 per 1000 words), compared to 11,345 total items (699.5 per 1000 words) in the newspaper articles. On the whole, the result of the chi-square test for total interactive metadiscourse is $X^2=180.908$, with a P value of 0.571, which is greater than 0.05. This suggests that there is no difference in the frequency of overall interactive metadiscourse.

RQ2: Ranked frequency of interactive metadiscourse in magazine articles and newspaper articles

Transition Markers

Transition markers include a number of interactive metadiscourse types to "signal additive, causative and contrastive relations in the writer's thinking, expressing relationships between stretches of discourse" (Hyland, 2019, p.53). They are essentially concerned with readers' interpretation of pragmatic connection between different arguments within content.

As shown in the examples below, transitions are realized by using conjunctive adverbs like *however* and *also,* coordinating conjunctions like *and* and *but,* and subordinating conjunction like *though*. The build-up of transition markers gives popularizers various choices to construct a sequence of claims throughout a text. In Examples 1 and 2, clusters of transition markers indicate contrast and shift in conceptions. They are used to clarify the relationship between ideas, *however* indicates an exception and *though* indicates a concession. On the other hand, transition markers such as *and* in Example 3 connects related alternatives, *but* signals exclusion to the preceding statement, and in Example 1, *also* provides additional information.

(1) The three males that didn't catapult, <u>however</u>, were killed, and the 30 further males they prevented from catapulting <u>also</u> got eaten.(Cosmos)

(2) The final straw, <u>though</u>, was seeing how the pandemic revealed a lack of structural support for families. Ms. Carey said, she feels sad <u>but</u> resolute about her decision.(The New York Times)

(3) A leader will pin down <u>and</u> discipline errant wolves, <u>but</u> less aggressive leaders won't. <u>And</u> when an alpha female dies, the pack disintegrate.(The New York Times)

As mentioned earlier, transition markers were the most frequently used subcategory of interactive metadiscourse in both corpora. The results suggest that the

predominance of transition markers emphasizes the popularizers' sensitivity in skillfully transforming logical reasoning into clear, understandable, and inferential guidelines to effectively popularize scientific data. Table 4 illustrates the ten most frequent transition markers in both corpora.

Table 4

Ten Most Frequent Transition Markers

Magazine articles			Newspaper articles		
Type	N	NF	Type	N	NF
and	4,493	243.4	and	3,784	233.3
but	775	41.9	but	623	38.5
also	437	23.7	also	295	18.2
so	299	16.2	so	250	15.5
because	184	9.9	because	169	10.5
still	158	8.6	while	145	8.9
while	150	8.2	still	93	5.8
however	84	4.6	however	85	5.3
yet	82	4.5	since	73	4.6
though	60	3.3	yet	50	3.1

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

A detailed look at the ten well-reputed transition markers in the magazine and newspaper articles shows that transition in each sub-corpus is signified by coordinating conjunctions (e.g., *and, but*), adverbs (e.g., *also, so, still, since, yet*), subordinating conjunctions (e.g., *because, while, though*), and conjunctive adverbs (e.g., *however*). As shown in Table 4, there is an overlap in some of the top ten attitude markers between the two corpora. According to the results, in both corpora, popularizers employed transition markers to emphasize various rhetorical functions. These markers, although mainly used to distinguish degrees or ranges, were realized by several linguistic resources fulfilling various semantic roles.

This finding is in accordance with Tessuto (2021), who suggests that various semantic functions of transitional markers play an important role in creating coherent and persuasive discourse. Consistent with this, Table 4 the words *and, but, also, so,* and *because* have been specifically identified in the popularized content, standing in the first five places of all transition markers employed. The overt use of such transitions clearly signals attempts by popularizers to challenge firmly held assumptions and compare them to new achievements. Thus, these markers can be effective tools for framing a range of adversative notions.

Frame markers

Frame markers allow writers to arrange the elements of propositional content in a clear and logical order. Their function lies in framing the formation and flow in a coherent style, thereby helping reader navigate through the text and "signal text boundaries or elements of schematic text structure" (Hyland, 2019, p. 59). These markers are used not only to indicate the chronological sequence of events but also to signal subsequent steps or a specific section or segment, and to inform readers about the division of content into sections for easier understanding.

In Examples 4 and 5, in the magazine articles, the adverb *then* indicates the next action in the sequence, and the adverb *next* is used to show the subsequent step. In Example 6, in newspaper articles, the adverbs *first* and *second* are used to indicate the initial and following actions. In popularizing science, the main purpose is to render it accessible to the general public by presenting it in a format with a clear starting and ending point, enabling readers to draw their own conclusions based on their perspectives. Thus, it is crucial for writers to frame their materials in an appropriate structure.

(4) *To use the device, the team then built an array of identical lenses.(Science News)*

(5) *One next step is finding how to produce many diodes at once.(Popular Science)*

(6) *First, strong public health capabilities are needed to identify, future outbreaks. Second, the NHS needs to be reinforced.(The Guardian)*

Differing from the results of the study by Morales and Gomez (2024), the present research suggests that frame markers were significant in content presentation and ranked third among all identified interactive markers in both corpora. To identify the predominant frame markers in each popular science commentary, Table 5 lists the ten most frequently used frame markers in the corpus of magazine articles and newspaper articles.

Table 5

Ten Most Frequent Frame Markers

Magazine articles			Newspaper articles		
Type	N	NF	Type	N	NF
so	299	16.2	so	250	15.5
first	219	11.9	first	241	14.9
now	214	11.6	now	191	11.8
then	159	8.7	last	167	10.3
well	141	7.7	then	124	7.7
(in) part x	112	6.1	well	124	7.7
last	67	3.7	next	107	6.6
next	61	3.4	(in) part x	90	5.4
(in) the x part	50	2.8	listing(a,b,c)	81	4.9
second	50	2.8	second	64	3.9

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

As presented in Table 5, eight out of the top ten frame markers overlap in both corpora, except the markers *(in) the x part* in the magazine articles and marker *listing(a,b,c)* in the newspaper articles. In line with these data, the most commonly identified frame markers are as follows: sequencers including adverbs *first, then, next, last, second,* phrases like *(in) the x part, (in) part x,* and enumerating marker like *listing (a, b, c)*, are used for establishing information sequences. A segment classifier tool like adverb *now* utilized to determine and categorize discourse goals, and adverbs *so* and *well*, are used as topicalizers to infer topic alterations and signpost new subjects. This aligns somehow with the findings of Kashiha and Marandi (2019), who observed that frame markers not only signal topics but also function as indicators of sequence. More precisely, these markers aid readers in perceiving the general structure of the popular science text, following the popularizers' line of reasoning. They also signify where writers aim to advance a specific aspect of the arguments and how they do so.

Endophoric markers

Endophoric markers direct readers to the different sections of the content, to visual aspects or instances located elsewhere in the text, or even to external sources, contributing to a cohesive and interconnected narrative. Endophorics are used to improve understanding by leading readers' focus to discussed topics subsequently or previously, thereby establishing a temporal or sequential link between ideas. Simply put, these interactive markers enable readers to connect various knowledge assertions, facilitate comparisons and provide additional context (Hyland, 2019). The following examples are representative instances of this. Since it is essential for readers to draw meaningful inferences from the ongoing discourse, they need an overview of previous or subsequent knowledge claims. The use of phrases like *show up later* in Example 7 or *studies before* exemplifies these directions. In Example 9, writer hooks the reader's attention by highlighting important visual data located within the content.

(7) It could mean there's a mystery cancer that will <u>show up later</u>.(Los Angeles Times)

(8) We carried out lots of <u>studies before</u> we did it, but then when it came to breaching the seawall, it's quite simple.(BBC News)

(9) <u>Figure illustrating</u> the concept of the ancestral recombination graphs.(Cosmos)

Table 6 displays the ten most frequent endophoric markers to compare their distribution in the two corpora and identify the predominant ones in each sub-corpus.

Table 6

Ten Most Frequent Endophoric Markers

Magazine articles			Newspaper articles		
Type	N	NF	Type	N	NF
x before	144	7.8	x before	110	6.8
(in) part x	112	6.1	(in) part x	90	5.6
Example x	75	4.1	Example x	47	2.9
x later	63	3.5	x above	42	2.6

(in) the x part	50	2.8	x later	39	2.5
x above	27	1.5	x earlier	32	1.9
x below	24	1.3	x below	20	1.3
x earlier	22	1.2	(in) the x part	12	0.8
Figure x	19	1	(in) section x	8	0.5
Table x	11	0.5	Figure x	6	0.3

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

As illustrated in Table 6, phrases are among the most frequently occurring endophorics in both corpora. Phrases like *x before, (in) part x*, and *Example x* rank highest among endophoric markers in each sub-corpus. From the data presented in the table, eight out of the top ten endophoric markers are overlapping in both corpora, except the markers *Table x* in the magazine articles and marker *(in) section x* in the newspaper articles. Overall, according to the study's result, these interactive markers serve as identifiers of what content will be delivered and help build anticipation for the forthcoming information. This is consistent with Memon et al.'s (2021) findings, which emphasize the necessity of incorporating endophorics in the text to fulfill readers' demands. This can enhance the content's clarity and readability.

Evidentials

Evidentials are used to indicate the source of information that originates outside the current study (Hyland & Jiang, 2020). These markers improve the credibility and reliability of the content by specifying the individuals or sources that support a particular stance (Hyland, 2019). More specifically, in popular science content, these interactive markers reference other researchers or experiments to boost readers' confidence in the writer's observation. Popular science writers mostly employ alternative terms such as scientists, doctors, researchers, and similar designations. These claims are evident in Examples 11 and 12. Additionally, in the corpus of this study, these markers showcase the epistemological voice of popularizers, declaring their perspective and level of certainty in disseminating scientific information.

(10)*According to scientists who have been searching for a vital building block of the Universe.(BBC News)*

(11) *NFFs like insect protein can contain a complete array of essential nutrients, according to the researchers.(Mail Online)*

Table 7 below lists the employed evidentials in the corpus of the magazine articles and newspaper articles.

Table 7
The Employed Evidentials

Magazine articles			Newspaper articles		
Type	N	NF	Type	N	NF
(date)/(name)	150	8.2	(date)/(name)	178	10.9
(to) cite X	1	0.06	(to) cite X	1	0.07

(to) quote X	1	0.06	(to) quote X	-	-
according to X	83	4.5	according to X	99	6.3
cited	2	0.2	cited	2	0.2
quoted	-	-	quoted	3	0.2

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

Table 7 shows that the most frequent markers referencing other resources in the magazine articles and newspaper articles are identical. They include markers *(date)/(name)* and *according to X* in magazine articles, with 8.2 per 10,000 words for the former and 4.5 per 10,000 words for the latter and in newspaper articles, with 10.9 per 10,000 words for the former and 6.3 per 10,000 words for the latter. As previously mentioned, evidentials are the least frequently used markers in the two corpora. One possible reason could be the nature of popular science content, which does not require citation or direct quotation from sources as much as academic genres do. This confirms the findings of Alharbi (2021) and Ruonan and Al-Shaibani (2022), who argued that due to the inherent characteristics of the content, there is a reduced necessity for the deployment of evidentials. Another reason might be the use of replacement expressions (e.g., scientists, doctors, researchers, and similar designations) that popularizers commonly use (see Examples 10 and 11 above).

Code glosses

Code glosses steer readers toward predetermined interpretations of arguments and help "to ensure the reader is able to recover the writer's intended meaning" (Hyland, 2019, p. 61). This type of interactive metadiscourse makes the content more accessible in two major ways: reformulation and exemplification (Hyland, 2007). The process of reformulation involves modifying the propositional meaning within the content by providing additional details or elaborating on specialized concepts. This procedure can be achieved through various code glossing markers, which help clarify the writer's argumentation using a range of lexical forms.

In Example 12, the writer attempts to deliver immediate complementary information through using parentheses. The verb *called* in Example 13 provides a precise term for better understanding. On the other hand, the process of exemplification clarifies the meaning of specific concepts by supporting them with examples. In Example 14, the prepositional phrase *such as* functions as an appositive to exemplify a general statement.

(12) Since there was also the presence of fatty acids (which have been used in early thermal weapons).(Mail Online)

(13) By analyzing human tissue and mice infected, researchers showed that immune cells called microglia.(Science News)

(14) And modern solutions, such as the building of urban gardens or adoption of agroforestry.(Science News)

As previously mentioned, code glosses were ranked as the second most frequently utilized subcategory of interactive metadiscourse markers in both corpora.

These findings confirm the goal of popularizing science, which is to disseminate scientific knowledge by providing sufficient explanations and simplifications to help readers navigate through potentially challenging technical terms and unfamiliar concepts. Table 8 below presents the ten most frequently used code glosses in each sub-corpus.

Table 8

Ten most frequent code glosses

Magazine articles			Newspaper articles		
Type	N	NF	Type	N	NF
dash -	1,119	60.7	dash -	1,334	82.3
or x	712	38.6	or x	486	29.9
(…)	663	35.9	(…)	406	25.1
called	142	7.7	such as	108	6.7
such as	139	7.6	say	99	6.2
say	104	5.7	called	92	5.7
for example	57	3.1	that is	69	4.3
known as	56	3.1	known as	56	3.5
that is	44	2.4	for example	32	1.9
for instance	31	1.7	for instance	12	0.8

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

As shown in Table 8, the *dash"-",* the coordinating conjunction *or* and the *parenthesis "()"* are among the highest frequency code glosses. Mostly these three interactive markers are used to indicate simple alternatives, exclusive and inclusive options, and supplementary information. Other markers, like the verbs *called,* and *say* and phrases like *such as, for example, known as, that is*, and *for instance* are primarily employed to elaborate on prior statements, ensuring that the reader grasps the content. These findings align with those of Algazo (2023), who argues that writers use code glosses whenever they intend to insinuate their intentions to the readers.

Discussion

Adhering to Hyland's analytical framework, this study examined the distribution of interactive metadiscourse markers across popular science commentaries. It demonstrated how popularizers use these linguistic resources to structure content and guide readers through the text. Corpus-based distributional and functional analyses revealed both broad similarities and subtle differences between the two corpora, highlighting the varied rhetorical strategies employed by writers. This can be attributed to several factors, such as the role and identity of the writers as popularizers and the characteristics of popular science materials as well-organized and deliberately crafted discourse.

The distinct distributional patterns of interactive metadiscourse markers identified in

this study provide valuable insights into how non-specialist readers navigate and comprehend popular science texts. Popularizers primarily focus on creating internal links within the text, using transitions to aid readers in following the intended meaning. However, writers are also dedicated to ensuring readers grasp their intended meaning through rephrasing by utilizing code glosses, dividing the propositional content, and outlining the text by employing frame markers. They reference other sections of the text through utilizing endophorics, and embed their knowledge claims while establishing their credentials by citing other sources with evidentials, thus offering a comprehensive perspective on the forms of interactive metadiscourse in popularized materials. Together, these features function as navigational aids, enabling readers to process scientific information more effectively and with greater confidence.

A detailed analysis of the ten most frequent markers in each subcategory reveals both shared practices and genre-specific adaptations, suggesting that the use of markers is deliberate and aligned with rhetorical goals and structural constraints. These findings align with and extend prior metadiscourse research. For instance, Hyland and Jiang (2020) observed a growing use of interactive markers in academic journals, indicating increased focus on reader engagement. In contrast, this study shows that in popular science genres, metadiscourse reflects different communicative priorities. Longer magazine articles rely heavily on transitions to maintain narrative flow and guide readers through complex content, while shorter newspaper articles use more frame markers and code glosses to organize and simplify information efficiently.

Unlike academic writing, which often assumes shared disciplinary knowledge and focuses on meeting expert expectations (e.g., Tessuto, 2021; Pilkington, 2019), popular science writing emphasizes clarity and explicit guidance for general audiences. By directly comparing magazine and newspaper subgenres, this study addresses a notable gap in the literature. Previous research (Ruonan & Al-Shaibani, 2022; Alghazo et al., 2023; Chen & Li, 2023) focused mainly on interactional elements in scientific contexts and did not examine subgeneric variation in popular science. This corpus-based study provides new empirical evidence that the distribution of interactive markers is shaped not only by the goal of simplifying content but also by subgeneric factors such as length, tone, and editorial style. Overall, this study deepens our understanding of how popular science writers adapt metadiscursive features to suit various audiences and formats. It underscores the rhetorical flexibility of interactive markers and their key role in enhancing comprehension, structuring discourse, and engaging readers in public-facing science communication.

Clearly, popular science content must be both engaging and clearly structured, using accessible yet purposeful linguistic choices. These materials aim to raise public awareness while appealing to general audiences. Writers often use metaphors and analogies to shape meaning and achieve specific communicative goals. Therefore, the language is typically informal and direct, sometimes incorporating a conversational tone. These stylistic choices make scientific information easier to understand by guiding readers through the text using navigational cues such as headings, links, visuals, and examples. Such features allow readers to focus on relevant sections and

assess the credibility and relevance of the information provided. In this narrative-driven genre, complex scientific ideas are presented in a way that is accessible to a broad lay audience. Hence, arguments must be clearly developed to help readers follow the logical progression of ideas and grasp key points. In sum, the findings highlight that interactive metadiscourse plays a crucial role in structuring content, ensuring coherence, and supporting the communicative purpose of popular science writing.

Accordingly, the outcomes of this study offer several pedagogical implications. First, learning resources can be improved by incorporating authentic examples from popular science texts, illustrating how interactive markers contribute to content organization and comprehension. Second, ESP and EAP instructors can be made more aware of the rhetorical functions of interactive markers across genres, promoting their critical use among learners. Third, increasing language learners' awareness of these markers can help them adjust their writing styles more effectively across different contexts. The study's insights may also prompt novice researchers to be more attentive to audience engagement strategies, ensuring their writing aligns with gatekeeper expectations. These findings highlight the importance of ongoing learning, especially for early-career researchers in non-English academic settings, to meet changing communication demands. Even course designers can further implement practical classroom activities to help students recognize and address areas for improvement in their writing. Future research may further advance metadiscourse literacy, and the examples provided in this study could serve as useful reference points. For instance, examining other metadiscourse categories, particularly interactional markers, within popular science genres could provide deeper insights into how writers construct audience engagement and manage stance. As popular science subgenres continue to expand in scope and accessibility, such research could significantly contribute to genre-based analyses and inform the development of more effective science communication strategies. Additionally, exploring metadiscourse use across emerging digital platforms, including blogs, podcasts, and social media, may reveal how rhetorical practices are adapted to suit various modes, audiences, and technological contexts.

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