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Research Article

Interactive Metadiscourse Use in Popular Science Subgenres

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Abstract

The modern digital era has made scientific knowledge more available to the lay audience crafting immediate access to the latest discoveries. This study aimed to investigate how interactive metadiscourse markers contributed to organizing and presenting ideas in popular science subgenres, including books, TV documentaries, magazine articles, and newspaper articles, to create engaging and accessible content for a lay audience. A corpus of 987,625 words was analyzed using AntConc, with Hyland's (2019) Interpersonal Model guiding the identification of marker frequency. The findings revealed 75,477 instances of interactive markers, with transitions and code glosses being the most frequently used. The analysis highlights both similarities and differences in marker usage across subgenres, illustrating how these tools shape content organization and engagement strategies. This study emphasizes the importance of developing explicit EAP/ESP resources to help language instructors and novice researchers, especially non-English L1 speakers, understand the rhetorical roles of interactive markers. Such resources can enhance genre-specific writing practices and improve audience engagement in the context of popular science discourse.

Keywords: EAP, ESP, interactive metadiscourse, language characteristics, popular science, corpus-based study

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Introduction

Popular science is a modern phenomenon characterized by the effective communication of scientific knowledge to general audiences, regardless of their level of expertise. This process is conducted by popular science content creators (or popularizers) who distribute scientific information through diverse mass media platforms, such as online news, television documentaries, popular science magazines, newspaper articles, books, and weblogs (Hyland, 2009). The digital era has made these resources more accessible, resulting in automatic exposure to scientific advancements. Popularizers act as mediators between the source sphere, comprising scientists and researchers, and the target sphere, comprising individuals within or outside the scientific community with varying levels of expertise in a particular field. They accomplish this intervention procedure by interpreting stringent scientific events into applicable and intelligible claims that resonate with everyday experiences (Moirand et al., 2016). This aspect of popularization is perceived as a manifestation of information translation from one kind of discourse to another (Myers, 2003).

Therefore, such materials highlight discoveries that can reshape audiences' perceptions, and to avoid confusion, content should be presented concisely. The popularization of science faces specific challenges. First, popular science materials should be written in an unambiguous style of language, avoiding technical terminology. Thus, the provision of materials characterized by required simplicity and contextual relevancy assumes paramount significance, as they are primarily used to stimulate the reader's understanding of scientific knowledge. Secondly, as Pilkington (2019) notes, it is crucial for popular science materials to adopt a coherent and persuasive structure that presents scientific concepts chronologically. By presenting information in an accessible way, these materials should aim to strike a balance between being informative and captivating to the general public.

Considering this, the use of metadiscourse markers can be regarded as an effective response to the aforementioned challenges. According to Kopple (1985), materials consist of two levels, the propositional level, which provides subject information, and the metadiscourse level, which helps readers organize, interpret, and evaluate the content. Metadiscourse is thus a form of "commentary" that enables content creators to instruct, connect, and collaborate with their audience while

simultaneously indicating their proficiency "to understand a text as it is intended, recognizing the writer's stance, seeing connections between ideas, and feeling involved in what is being communicated" (Hyland & Jiang, 2022, p.1). Fundamentally, metadiscourse functions as a filter, helping present content in a way that aids the audience in processing and comprehending arguments. Popularizers use metadiscourse to organize and enrich their writings, offering interpretive support to their readers. According to Hyland's (2019) interpersonal model (a comprehensive refinement of the 2005 model), metadiscourse has been divided into two primary categories: interactional and interactive markers. Interactional resources are personal, reflecting the author's stance on ideas and their attitude towards the audience to foster mutual discourse. This type of metadiscourse is necessarily "evaluative and engaging, expressing solidarity, anticipating objections and responding to an imagined dialogue with others" (Hyland, 2019, p. 58). However, Hyland (2019) believes that interactive markers are utilized by writers to convey information about the target audience. These markers assist content creators in arranging the content in a way that aligns with the needs and expectations of the readers. As Hyland (2019) elucidates, the interactive dimension of metadiscourse enables writers to take into account the readers' "probable knowledge, interests, rhetorical expectations, and processing abilities" (p. 57).

Therefore, the intrinsic importance of interactive markers in framing scientific developments for lay audiences (Hyland, 2019) cannot be overstated. The importance of interactive markers and the following key reasons led us to focus our research on them. Primarily, interactive markers guide readers through complicated content, enabling them to navigate key sections and ensuring clarity. In fact, writers emphasize these markers to enhance textual organization and address audience preferences. Moreover, this category of metadiscourse facilitates audience comprehension of the writers' purposed message (Memon et al., 2021). Additionally, it helps writers define content and present knowledge claims that assist the audience in grasping the intended interpretation. In popularizing scientific discoveries, popularizers use interactive markers to engage audiences within the rhetorical context of popularization (Hyland, 2019). Furthermore, in transferring essential interpretations and meanings between professional and popular science genres, interactive features are "central to these translations of meanings across

genres" (Hyland, 2019, p. 114). Several scholars have also contended that interactive metadiscourse exhibits effectiveness not solely in engaging audiences within popularized content, as delineated by Jiménez (2005), Pilkington (2016), Ruonan and Al-Shaibani (2022), and Hastomo and Aminatun (2023), but also in enhancing the general public's interpretation and comprehension of scientific concepts through clarifying implicit aspects of knowledge claims.

Despite their significance, little attention has been given to the characteristics of interactive markers across informative and palpable subgenres of popular science, regarding their similarities, differences, and manifestations. Besides, it is unclear whether novice researchers are aware that these figurative language devices function as a fundamental component within the textual features designed to enhance reader engagement, consequently improving the overall effectiveness of scientific communication. Neglecting this awareness can lead to significant difficulties in properly applying these discursive practices. For example, these less-experienced writers cannot provide appropriate interactive metadiscourse in their text because they do not know where readers will need help in interpreting points, where greater elaboration or clarification are required by using these markers. Another unresolved issue might be how interactive markers utilized in popularized scientific contents may shape the readers' inferences about the content and manipulate their attention.

Overall, unawareness of the critical role of interactive metadiscourse in popularized subgenres may lead to a feeling of uneasiness in both writers' and readers' parts. That is, the lack of knowledge about the use and locations of interactive markers among inexperienced writers may render their writings difficult to comprehend and diminish their readability. In other words, writers with little knowledge of how to use interactive markers may fail to communicate effectively with their audience in a reader-friendly manner. Motivated by such assumptions, and to address issues mentioned above, the current study sought to clarify how variations of interactive markers (e.g., transition markers, frame markers, endophoric markers, evidentials, and code glosses) impact the overall effectiveness of communication and influence the functions they carry out across distinguished subgenres of popular science materials (i.e., books, TV documentaries, magazine articles, and newspaper articles).

Literature Review

Popular Science

Popular science materials typically focus on abstract concepts, scientific discoveries, and the immediate reporting of scientific novelty. Researchers in the social sciences and communication investigate how science is popularized, which includes simplifying, explaining, and scattering scientific conceptualizations to the general public. This process employs language features that link propositional content and the audience's prior knowledge, addressing other social and political implications (Hyland, 2009; Fu & Hyland, 2014; Pilkington, 2016).

There are some factors that make popular science appealing. First, it must be interesting. According to Pilkington (2019), popular science materials should be published in a structured format using particular linguistic jargon. These scientific resources aim to increase social awareness inductively while also being interesting to the general public. Second, simplicity is crucial. Turney (2007) notes that certain metaphors and analogies are frequently employed in popular science, creating specific representations that writers adapt for their purposes. Consequently, popular science often uses more informal language in a more direct way, sometimes including conversational style (Bellés-Fortuño, 2016).

Pandey et al. (2022) emphasize the importance of popularizing science to inform and raise public awareness, comparing it to sowing seeds of knowledge. They argue that popularizers enrich this process by using metadiscourse to structure content, re-contextualizing and reformulating source materials to make them understandable and relevant to a lay audience. Hence, Hyland (2009) and Hudoshnyk and Krupskyi (2022) view popularization as the process of explaining, rephrasing and reinterpretation of scientific knowledge claims, wherein particular word framing and linguistic domains are used to interact with audience. Belas (2014) highlights the importance of theoretical coherence and persuasiveness in popular science, stressing the need for active dialogue between writers and readers.

In recent years, many scholars, particularly Myers (2003) and Pilkington (2016, 2018, 2019), have shown a keen interest in the use of linguistic elements in the popularization of science. Pilkington (2018) investigated interactive mechanisms that lead to reader engagement, whereas Pilkington (2019) studied scientific terminology in popular science texts, shedding light on the strategies that result in

the use of clarified and engaging language elements, among other valuable findings. Meanwhile, several researchers have conducted comparisons of discourse features between popular science and scientific articles (e.g., Bellés-Fortuño, 2016; Hyland, 2010).

Interactive Metadiscourse in Popular Science Genres

The term 'metadiscourse' was introduced by a structural linguist in the late 1950s, referring to understanding language in use. Hence, metadiscourse refers to a producer's efforts to shape a receiver's perception of content (Hyland, 2019). Kopple (2012) emphasizes the importance of metadiscourse for illuminating language structures, enabling cross-disciplinary or cross-linguistic analysis, and enhancing communication by aiding text interpretation and elaboration.

According to Hyland and Jiang (2020), the boundary between interactional and interactive elements is not clear; they are "two sides of the same coin" (p.3). They describe interactive metadiscourse as features for linking material, offering elaborations, signaling text stages, and referring to other information within the text, serving both cohesive and pragmatic purposes. These markers do more than just bind the text together; they create an internal dialogue with the audience. This reflects the writer's judgment in presenting information persuasively for specific readers.

Although interactive and interactional metadiscourse are crucial for information transition, considerable research has explored cross-genre analysis of interactional markers in popular and professional science materials. This includes comparisons between research and popular science articles (Jiménez, 2005), popular science and opinion articles (Fu & Hyland, 2014), and popular science in nutrition and academic research articles (Saidi & Saiedi, 2020). However, despite their common goals, these studies have predominantly focused on the examination of how writers communicate with readers and the tools they employ for this purpose.

On the other side, some previous investigations scrutinized variations in the usage and frequencies of interactive and interactional metadiscourse markers in deafened contexts, for example scientific discourse like medical science (e.g., Firdaus & Shartika, 2021; Ghahremani Mina & Biria, 2017; Nugrahani & Bram, 2020), and popularized content, such as news media (e.g., Yin, 2022), social media (e.g., Huang et al., 2023), or social science (e.g., Ruonan & Al-Shaibani, 2022).

While these studies are crucial for our knowledge of the utilization of metadiscourse within various materials, they arguably do not provide information about the common mechanisms shaping the use of interactive markers and their impact across popularized content. Moreover, even though a small number of comparative-based studies have been carried out in terms of interactive markers across diverse academic registers (e.g., Alghazo et al., 2023; Hyland & Jiang, 2020; Khedri & Basirat, 2022; Memon et al., 2021), no previous research has explored interactive metadiscourse among popular science subgenres.

The Present Study

As was alluded to above, previous research has extensively explored the general features and effectiveness of popular science communication but has not adequately detailed which linguistic elements specifically enhance audience engagement and comprehension in particular popular science subgenres. This gap in the literature is notable because, as was previously mentioned, most existing studies have mainly focused on the function of interactive metadiscourse in the context beyond popular science, yet they have overlooked the nuanced role of interactive metadiscourse in influencing audiences' characteristics and preferences in each subgenre. Therefore, there is a compelling need to direct attention toward the examination of interactive markers, which represents a new and essential focus in the analysis of popularized scientific materials across diverse subgenres.

To the best of our knowledge, our investigation, for the first time in the literature, seeks to analyze the language characteristics, including similarities, differences, and influences, exhibited by interactive markers and their variations within each popular science subgenre (i.e., books, TV documentaries, magazine articles, and newspaper articles). More precisely, the study aims to clarify how ideas are organized and presented, examining the factors that contribute to the widespread appeal of popular science subgenres to a broad readership. To this aim, the study sought answers to the following research questions:

1. What are the main interactive metadiscourse markers employed by popular science content creators?
2. Are there any significant differences across popular science subgenres in terms of their utilization of interactive metadiscourse markers?

Method

Design of the Study

The present research adopted a mixed-method design using both quantitative and qualitative data analyses. The quantitative phase consisted of frequency counts of interactive markers in four sub-genres of popular science, including books, TV documentaries, magazine articles, and newspaper articles. Subsequently, a qualitative phase employed Hyland's (2019) model to analyze and describe the similarities and differences between them in applying these resources, offering a comprehensive exploration of interactive markers in popular science materials.

The Corpus

The corpus prepared for this investigation comprises a heterogeneous range of popular science materials, precisely chosen to enable a comprehensive analysis of interactive metadiscourse across various subgenres. The corpus contained four distinct sub-corpora: 60 chapters were extracted randomly from 30 popular science books (281,094 words) published between 2013 and 2024; transcriptions of 50 popular science TV documentaries (359,722 words) produced between 2015 and 2024; 150 popular science magazine articles (184,623 words) published between 2018 and 2024 and 150 popular science newspaper articles (162,202 words) published between 2015 and 2024.

The criteria for assembling the corpus were directed by several considerations. Primarily, to ensure a broad representation of science-related topics, all four sub-corpora in this collection follow the thematic heterogeneity principle, covering a wide range of scientific topics, such as geology, anatomy, media, biology, neurology, nutrition, ecology, technology, climate change, and COVID-19. Thus, materials were selected based on their direct relevance to these popular science themes.

Another crucial criterion involved sourcing data from reputable and accessible online repositories, well-known for their credibility and accuracy in disseminating scientific information. This entailed assembling materials from databases, such as *Z-lib.org, pdfbooksworld.com,* and *sciencebooksonline.info* for books; *BBC Earth, National Geographic,* and *NOVA on YouTube* for TV documentaries; *Sciencenews, Scitechdaily, Nationalgeographic, Popsci, Wired,*

Cosmosmagazine, and *Neurosciencenews* for magazine articles; and *Nytimes, The Guardian, News.sky, Latimes, Washingtonpost, BBC,* and *Dailymail* for newspaper articles. An overall overview of the corpus is provided in Table 1. These online platforms are well-known for their reliability and adherence to accurate editorial standards, ensuring the integrity of the information collected for this study.

Finally, priority was given to materials published between 2013 and 2024 to capture contemporary scientific perspectives and discussions (see Table 1). The corpus consists of 987,625 words, which was meticulously prepared to fulfill the overarching objectives of the present study. Hence, the corpus size offers a robust basis for exploring the functions of interactive metadiscourse used across different popular science subgenres. To capture a comprehensive representation of popular science discourse, the selection criteria for the content of each subgenre have been developed, aiming to encompass the breadth and depth of materials.

Table 1
Overall Description of the Corpus

Genres	Sources	Numbers	Words	Year
Books	Z-lib.org, pdfbooksworld.com, sciencebooksonline.info	60	281,094	2013-2024
TV documentaries	BBC Earth, National Geographic, NOVA on YouTube	150	359,722	2015-2024
Magazine Articles	Sciencenews, Scitechdaily, Nationalgeographic, Popsci, Cosmosmagazine, Neurosciencenews Wired	150	184,623	2018-2024
Newspaper Articles	Nytimes, Theguardian, News.sky, Latimes, Washingtonpost, BBC, Dailymail	150	162,202	2015-20224

Analytical Model

Hyland's (2019) classification of interactive metadiscourse was adopted and its five subcategories are described as follows:

Transition markers: conjunctions and adverbial phrases that highlight additive (*and, furthermore*), contrastive (*in contrast, however*), and consequential (*thus, consequently*) connections within arguments to help audiences follow the discourse.

Frame markers are diverse features used to structure content, sequence parts (*first,*

then), label stages (*to summarize*), announce goals (*I argue here*), and shift arguments (*well, right*).

Endophoric markers are expressions that direct audiences to other sections within the content (*refer to the next section*) to aid argument comprehension.

Evidentials are devices used to indicate the source of knowledge claims originating outside the current content (e.g., according to).

Code glosses are words (*called, for example*) that provide additional information through rephrasing, explaining, or elaborating to help audiences understand the intended meaning.

On the other hand, interactional resources center on the relationship between writers and audiences (*consider, should*). Writers use various linguistic tools to convey their viewpoints (*unfortunately, perhaps*) and establish a connection with their audience (*our, in fact*). The purposes of such markers include persuading, informing, or engaging the audience.

Procedure

The primary goal of the current study was to scrutinize the use of interactive metadiscourse markers across various subgenres of popular science such as books, TV documentaries, magazine articles, and newspaper articles. To fulfill this goal, a detailed four-step methodology was implemented. Initially, materials were randomly collected from leading websites listed in Table 1 for each subgenre, generating distinct sub-corpora. This exact procedure guaranteed that the collected data was representative of a broad range of popularized writings. Following that, the Antconc 3.5.8 concordance software (Anthony, 2019), renowned for its capacity to analyze text corpora, became the tool to estimate the frequency of Hyland's classification of interactive metadiscourse within each sub-corpus. This tool aided in the identification of the most frequently used interactive markers in each subgenre, allowing for a systematic and impartial analysis.

In the third step, descriptive statistics were applied to calculate the occurrence frequencies of each interactive marker based on the list compiled by Hyland (2019). This quantitative investigation permitted a comparison of the usage frequency of numerous interactive markers across subgenres. The results were reported in both raw numbers (N) and normalized frequency (NF) per 10,000 words. In this step, chi-square tests were conducted using IBM-SPSS 27.0 to reveal

significant differences among four subgenres in the use of interactive markers.

Finally, qualitative analysis was employed to discern the similarities, differences, and functions of different linguistic tools across the corpus. In this step, some examples from the corpus were extracted and interpreted to clarify their functions. This process aligns with Hyland's (2019) perspective that emphasizes meaning in context and how language is employed, rather than depending solely on dictionary definition. This last analytical step deepened the comprehension of the inclusion of interactive metadiscourse in popular science writing, which promoted the identification of commonalities and variations in their application across diverse subgenres.

Results and Discussion

Main Interactive Metadiscourse Markers in Popular Science Content

The primary research question of the current study addresses what main interactive markers are employed by popularizers. Table 2 presents a thorough analysis of the use of different interactive metadiscourse features. Moreover, to establish the statistical significance of the findings, the results of chi-square tests for each category are also presented in Table 2.

Table 2

Distribution of Interactive Markers in all Subgenres

	Books		TV docs		Magazine articles		Newspaper articles		Total N of each type	chi square test	
Interactive markers	N	NF	N	NF	N	NF	N	NF		x^2	sig.
Transitions markers	12,583	447.7	14,935	415.2	7,197	389.9	5,856	361.1	40,571	164.086	<.001
Frame markers	3,372	119.9	7,102	197.4	1,968	106.6	2,008	123.8	14,450	52.451	<.001
Endoporich markers	1,479	53.7	886	24.6	578	31.3	431	26.5	3,374	6.595	<.001
Evidentials	856	30.5	162	4.5	237	12.9	283	17.5	1,538	3.568	<.059
Code glosses	7,667	272.7	1,911	53.2	3,167	171.5	2,767	170.6	15,512	120.441	<.001
Total	25,989	924.6	24,996	694.9	13,147	712.1	11,345	699.5	75,445	202.2	<.001

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

According to the data in Table 2, the corpus evaluated in this study includes a total of 75,477 items of interactive metadiscourse markers. The chi-square value showed a significant difference in the use of interactive markers across all four subgenres ($X^2 = 202.2$, $p < .001$), indicating varied usage of these markers among different types of popular science content. The chi-square value, along with the total number of interactive markers, demonstrates the overall variation and distribution of these markers among the subgenres. From this table, interactive markers are most commonly used in books (NF = 924.6), with a substantial distinction observed in magazine articles (NF = 712.1), followed by newspaper articles (NF = 699.5), and lowest frequency in TV documentaries (NF = 694.9), with frequencies normalized per 10,000 words.

Transition markers with 40,571 incidences and code glosses with 15,512 incidences were identified as the top and second most frequent features employed in the corpus. Subsequently, there were 14,450 incidences of frame markers, 3,374 incidences of endophoric markers, and evidentials with 1,538 incidences being the least frequent markers. The distributions of linguistic metadiscourseal items reveal interesting tendencies in their utilization patterns.

These markers were employed by popularizers to enhance the cohesiveness and coherence of their produced materials, ensuring that their arguments are well-supported with reliable sources.

Variations in Interactive Markers Use across Popular Science Subgenres

The second research question addressed differences across popular science subgenres in terms of their utilization of interactive metadiscourse markers. Table 2 also highlights variations in the use of interactive markers across all four popular science subgenres.

Transitions Markers

As shown in Table 2, the most commonly used subcategory of interactive metadiscourse is transition markers, specifically in books (NF = 447.7) and TV documentaries (NF = 415.2), compared to magazine articles (NF = 389.9) and newspaper articles (NF = 361.1) with the least frequent markers. Based on the chi-square test result ($X^2 = 164.068$, $p < .001$), there is a significant difference in the frequency of transitions.

Transition markers consist of addition, comparison, and consequence

(Hyland, 2019). In the present study, the most frequent transitions are *and, also, again, but, still, while, however, rather, so, yet, though, because,* and *since* (see Appendix, Table 1).

The higher frequency of transition markers may result from a deliberate choice taken by popularizers to boost clarity as well as consistency in their communication so that audiences can effortlessly follow the flow of arguments. Such markers accommodate the moderate integration of new perspectives and findings, enriching the overall quality of the scientific content. For instance, examples 1 and 2 show the use of markers, such as *and, also,* and *again,* that indicate the additional points. These examples suggest that producers use concise, recognizable markers to establish a clear chain of claims.

(1) *I was back on my feet in 10 weeks,* ***and*** *I just made a deal with myself* ***and*** *the deal was that. (TV documentary: Heal, 2017)*

(2) ***But*** *it will* ***still*** *be useful.* ***And****, as with any technology, progress doesn't come with the passage of the years* ***but*** *with investment. (Newspaper article: Turrell, 2022)*

Other markers, including *but, still, while, however,* and *rather* are employed in scientific claims to describe comparative or distinguishing concepts. Since popular science content attempts to challenge firmly held views and compare them to new achievements (Myers, 1991), these markers can be effective tools for framing a range of adversative notions (Examples 3 and 4).

(3) *Increasing the speed to 10 mph will also increase your fuel efficiency,* ***since*** *it can't get any lower.* ***But*** *it might not be the best gas mileage. (Magazine article: Allain, 2022)*

(4) ***Because*** *of the many variables associated with leading a group of people, it is important to keep the discussion as simple as possible. (Book: Holland, 2022)*

To adequately popularize scientific data, popularizers ought to skillfully reframe logical reasoning into understandable causal and inferential perceptions. This entails employing a range of transition markers, such as *so, yet, though,* and *since*. In examples 3 and 4, writers imply unexpected or conflicting explanations for subsequent events. Similar to the findings of several studies (Doiz & Lasagabaster, 2022; Khedri & Basirat, 2022; Ghahremani Mina & Biria, 2017), it might be posited

that popularizers have to acquire the art of elaborating their research discoveries to fascinate audiences.

Frame Markers

Considering Table 2 above, it is worth noting that frame markers are most frequently employed in TV documentaries (NF = 197.4) and newspaper articles (NF = 123.8), nearly trailed by books (NF = 119.9). Magazine articles (NF = 106.6) contained the least frequent markers. The chi-square test result for frame markers indicates a significant difference ($X^2 = 52.451$, $p < .001$) across subgenres.

Frame markers in the present corpus include a number of interactive markers with different aspects (e.g. sequencers, classifiers, announcers, and topicalizers) in arranging the elements of propositional content and in discourse organizing of popular science materials (Hyland, 2019). According to the findings, the most commonly identified frame markers are as follows: Knowledge claim sequencers for establishing information sequences include markers, such as *first, then, (in) part x, (in) the x part, next, last, second, (in) chapter x,* and *listing (a, b, c, so on)*. Discourse stage classifiers are utilized to determine and categorize discourse goals, using tools like *now, overall* and *so far*. Objective announcers that involve markers like *want to*, *goal*, and *focus* are employed for announcing discourse goals, while topicalizers encompass linguistic devices like *so*, *well*, *now,* and *back to* are used to infer topic alterations and signpost new subjects (see Appendix, Table 2). In popular science materials, these markers are used not only to indicate the chronological sequence of events, but also to signal subsequent steps, to mark a specific section or segment, and to inform audiences about the division of content into sections for easier understanding (Examples 5 and 6).

(5) *Moreover, as we shall see in the* ***last chapter of the book****, in the not so distant future we might again have to contend with non-sapiens humans. (Book: Harari, 2014)*

(6) *The* ***second*** *thing to tackle is scaling of production. The* ***next*** *step will be to investigate how to scale production. (Newspaper article: O'Neill, 2022)*

Furthermore, examples 7 and 8 demonstrate how writers employ these frame markers to summarize the information presented up to certain points within a discourse section or emphasize the move to another facet of their findings and

introduce a new topic.

(7) ***So*** *the* ***next*** *challenge is to see inside the body. (TV documentary: Colour, 2015)*

(8) ***Next****, we will* ***focus*** *on how molecular changes inherent to this pathway alter the perception and duration of pain. (Book: Ambron, 2022)*

In accordance with previous research (Alghazo et al., 2023; Carri´o-Pastor, 2021; Ruonan & Al-Shaibani, 2022), the findings of this study confirm that frame markers may perform many functions in popular science productions, implying various stages within popularized content. More precisely, they help audiences understand the material's structure, follow the reasoning, and identify focus shifts in arguments.

Endophoric Markers

As illustrated in Table 2, endophorics are most commonly seen in books (NF = 53.7) and in magazine articles (NF = 31.3) followed by newspaper articles (NF = 26.5) and TV documentaries (NF = 24.6) with a little differentiation. Based on the chi-square test result ($X^2 = 6.595$, $p < .001$), there is significant difference in the utilization of these features. Findings suggest most frequent endophorics, such as *(in) part x, x later, (in) chapter x, (in) the x chapter, (in) this chapter, x below,* and *(in) section x* offer the audience a preview insight so that the forthcoming arguments would be presented (see Appendix, Table 3).

In accordance with Hyland (2019), endophorics are employed to enhance comprehension by drawing the audience's attention to subsequently or previously discussed matters, as well as to build a temporary or sequential link among ideas. In simpler terms, these markers enable the audience to set up connections between arguments to make comparisons and retrieve additional context. The study shows these markers identify upcoming content and create anticipation for new information. (Examples 9 and 10).

(9) *The* ***next section of this chapter*** *and* ***the following chapters*** *will demonstrate the importance of the centrality measurements. (Book: Segev, 2021)*

(10) *When we get auroras and solar storms that hit the Earth, is actually* ***in the top part*** *of the declining phase of cycle. (Magazine article: Garbas, 2022)*

Other common markers like *x before, x earlier*, and *x above* are carried out as backward references, directing the audiences' consideration to earlier mentioned points or sections. These tools provide an overview of prior knowledge, enabling audiences to draw meaningful inferences from the discourse. (Example 11).

(11) *Life on Earth could have begun much* ***earlier*** *than previously thought, according to a new study. (Newspaper article: Sky, 2022)*

(12) ***Figure 15.3*** *shows such a development using an* ***example*** *from Laos; it should be noted that this* ***figure*** *serves the purpose of illustrating indirect road effects. (Book: Zwahlen, 2022)*

In example 12, popularizers used endophorics, namely *Figure* 15.3, *example* as references to visual aspects or instances located elsewhere in the text (Nugrahani & Bram, 2020). Upon analyzing the data of the study, it was found that tools such as *Example x, Figure x*, and *Table x* are the most frequent endophorics used to lead audiences towards visual representations such as pictures, tables, and figures or to signify supplementary elements, such as examples, titles, or excerpts. These findings are supported by the results of previous studies (e.g., Akoto, 2020; Herriman, 2022; Ruonan & Al-Shaibani, 2022), which asserted that the authors used endophoric markers to provide more precise information referring to the different sections of their materials.

Evidentials

According to the findings, evidentials are most commonly used in books (NF = 30.5) and newspaper articles (NF = 17.5), followed by magazine articles (NF = 12.9), with TV documentaries showing the least frequent use (NF = 4.5). The related chi-square test result indicates a slight difference ($X^2 = 3.586$, $p < .059$). Therefore, these markers are among the least utilized subcategories of interactive metadiscourse. This paucity of types of evidentials confirms the findings of Alharbi (2021), who argued that due to the inherent characteristics of the content, there is a reduced necessity for the deployment of evidentials. Similarly, within popular science discourse, popularizers mostly employ alternative terms such as scientists, researchers, or similar designations. According to the results of this study, the utilized evdintials are *(date)/(name), (to) cite X, (to) quote X, [ref. no.]/[name], according to X, quoted*, and *cited* across all four subgenres (see Appendix, Table 4). The study suggests that popularizers use evidentials to acknowledge research,

support claims, and build audience confidence (Examples 13 and 14).

(13) ***Matthew J. Czarny et al.'s study from Johns Hopkins University in 2008 cites*** *84% of medical students and 81% of nursing students surveyed reported watching medical television dramas.(Book: Kendal & Diug, 2017)*

(14) *From grizzly bears to earthworms, scientists are arguing that five common personality traits…*

By Jim Robbins

March 5, 2022 *(Newspaper article)*

The study reveals that this interactive metadiscourse attributes content to scientific surveys, experiments, and credible research. This result aligns with the findings of Herriman (2022) and Hastomo and Aminatun, (2023) who emphasized the significance of implementing evidentials for validating propositions. Additionally, these markers reflect the epistemological voice of popularizers, revealing their perspective and certainty in presenting scientific information. As a result, these markers make it possible for audiences to assess the reliability of the content presented.

Code Glosses

In the present study, these features are most frequently used in books (NF = 272.7), followed by magazine articles (NF = 171.5), closely trailed by newspaper articles (NF = 170.6) and TV documentaries (NF = 53.2) with the least frequent amount. The chi-square test result for code glosses shows a significant difference ($X^2 = 120.441$, $p < .001$) across subgenres.

In popularized materials, code glosses guide readers toward predetermined interpretations of scientific arguments (Hyland, 2019). The results showed this type of interactive metadiscourse is utilized by popularizers whenever they intend to insinuate their intentions to the audiences. Markers, such as *for example, such as, parenthetical gloss,* and *for instance* have been extensively utilized with the objective of strategically orienting their audiences (see Appendix, Table 5). Writers may employ these markers to upgrade clarity and increase the audiences' perception (Examples 15 and 16).

(15) *I myself would be blind in at least one eye* ***(from retinal detachments),*** *walk with a limp* ***(from a complex ankle fracture)*** *and possibly be dead* ***(from urosepsis)****. (Newspaper article: Marsh, 2022)*

(16) *Sleep,* ***for instance****, wakes people up regularly and is associated with heart disease. (Magazine article: Connellan, 2021)*

In the context of example 15, *parenthetical gloss* is primarily used to elucidate specific instances, including (or excluding) particular points in presenting findings, and deepen the meaning of some expressions within the text. Moreover, these markers may be employed to clarify complex scientific concepts by providing similar expressions or simplified examples.

Other prevalent code glosses, such as *or x, known as, in fact, called, which means, that means, I mean,* and *the dash symbol* are employed to impart complementary meanings and descriptions to scientific statements. This is particularly noticeable when popularizers attempt to influence audiences' intuition and also to optimize the precision and clarity of scientific claims (Examples 17 and 18).

(17) *In this book, we would,* ***in fact****, like to investigate what form the mind takes as we go deeper into the future. (Book: Plebe, Perconti, 2022)*

(18) "*One hypothesis is that the sun shines on one side of the asteroid,* ***which means*** *that side is hotter,*" *Lim* ***says****. (Magazine article: Young & Young, 2022)*

In example 18, writers logically utilize code glosses to revise, articulate, and equip knowledge claims with alternative explanations, with the goal of effectively disseminating research findings. Additionally, writers use these markers to elaborate claims and make previous arguments more accessible to the audience. In accordance with previous studies (Herriman, 2022; Huang et al., 2023; Khedri & Basirat, 2022), it is argued that code glosses are used to provide informative, concrete, and tangible examples along with outlining and reinforcing preceding statements or contentions in the text.

Overall, the analyses based on corpus data of distribution and functions in linguistic content have shown that there are broad differences in the use of interactive metadiscourse across the four subgenres of popular science. Based on this observation, it may be deduced that popular science writers mostly modify their strategies and styles based on the specific genre or context in which they produce content. The findings also highlight the deliberate use of these markers to make scientific content engaging and comprehensible, reflecting the unique demands of popular science communication.

Conclusion

This study investigated the use of interactive metadiscourse markers in popular science materials across different subgenres, including books, TV documentaries, magazine articles, and newspaper articles. The results revealed that popularizers used a spectrum of interactive markers, such as transitions, frame markers, endophoric markers, evidentials, and code glosses. The research highlights the importance of providing detailed descriptions of each marker in the compiled corpus. It concluded that 25,989 interactive markers were used in books (NF = 924.6), whereas the number of interactive markers in TV documentaries was 24,996 (NF = 694.9), in magazine articles 13,147 (NF = 712.1), and in newspaper articles was 11,345 (NF = 699.5) (in terms of items per 10,000 words).

This implies that, in the realm of popular science, which is described as a narrative style of disseminating knowledge, popularizers present complex scientific concepts in a way that is accessible to a range of lay audiences. Thus, every single argument must be described in detail so that the audience's mind can manage to follow the logical sequence of the ideas and understand the key points.

It was discovered that transition markers, as the most frequent interactive markers, were more prevalent in books and TV documentaries compared to other subgenres. Considering the sequential structure of books, transitions were employed to assist readers in following the progression of knowledge claims, navigating through the written content, and exploring topics. Similarly, due to the structural integrity of the content of TV documentaries, information was often presented clearly and concisely.

Code glosses, the second-most frequent interactive markers, were the prevalent used markers in books, followed by magazine articles and newspaper articles. Contents in magazine and newspaper articles are typically presented as a combination of written and visual elements with designed layouts and updated information. Considering that code glosses help to provide clarification or correction for information and provide required context, authors in these subgenres made an effort to facilitate reader engagement and comprehension. In the linear and textual content of books, code glosses were used to provide additional explanations. Writers needed this type of interactive marker to elucidate technical and unfamiliar assumptions that were brought forth throughout the book. They employed code

glosses to ensure that readers could trace the content, whether they had a background in the subject matter or not.

Frame markers were the third-most frequent interactive markers. It was discovered that they were employed more commonly in TV documentaries and newspaper articles. Considering the role of these interactive markers in framing discourse sequences, TV documentary producers made a considerable effort to edit visuals to communicate their message and engage audiences in a particular way. On the other hand, authors in newspaper articles had specific requirements for frame markers as section breaks to organize information. For instance, frame markers were the main tools to introduce the topic, present key points, and provide concluding statements.

Endophoric markers were found to be the most common interactive markers utilized in books and magazine articles. Considering that books are usually formal and authoritative resources with a vast array of references and precise attention to detail, writers employed endophorics to maintain intertextual connectivity, enable readers to navigate through the text, read the content linearly, and retrieve previously introduced concepts. The content of magazine articles often includes short points and informative subject matter; hence, writers strategically use endophorics to direct readers back to previous sections or paragraphs within the same article. That improved the flow of the text, assisted audiences in establishing connections, and preserved the consistent comprehension of the current topic.

Evidentials, the least used markers in the corpus, were more often observed in books and newspaper articles. This reflected that book writers usually dealt with factual and objective arguments in a scholarly format. It necessitated a tendency to use evidentials to strengthen the credibility of scientific findings and to provide supporting evidence to substantiate claims. Similarly, the highly frequent incidences of evidentials in newspaper articles indicated that writers needed to employ evidence to reinforce the credibility of the knowledge claims, emphasize the importance of up-to-date and contextualized information, and subsequently bolster the credibility of the claims.

Given that the current study has confirmed the ubiquity of interactive metadiscourse markers in a relatively large corpus and their role in promoting comprehension effects, it might offer invaluable pedagogical implications for a wide

range of audiences with varying needs.

Accordingly, the results of the current study would help: i) ESP and EAP material developers enhance learning resources by explicitly integrating authentic examples from popular science materials. These exercises highlight how interactive markers contribute to the overall structure and intelligibility of content in real-world contexts; ii) ESP and EAP instructors sensitize learners and novice members to the various rhetorical functions of interactive markers in different genres and inspire them to use these markers critically; and iii) Language learners develop a keen awareness of the utilization of interactive markers across distinctive genres and tailor their writing style as needed. Likewise, with the advent of findings about interactive metadiscourse, novice researchers may be alerted and become more conscious of engaging with their audiences in new and dynamic ways to fulfill gatekeeper expectations. Taken together, these findings endorse a mindset of continual learning, where inexperienced researchers, particularly in non-English academic contexts, actively look for opportunities to increase their repertoire of interactive metadiscourse in response to shifting communication needs and keep up with language conventions.

Further investigation is expected to advance current literacy levels in this domain, and examples provided in the current study may prove beneficial in this regard. For example, other categories of metadiscourse (interactional markers) in popular science genres might also be examined to gain an in-depth understanding of how writers deploy those markers to engage and interact with their target audience. Finally, as the popularity and accessibility of popular science subgenres grow, the findings of this study can be worthwhile for scholars who are interested in genre analysis and may pave the way for future research directions.

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Appendix

The most frequent markers

Table 1

Transitions

Books			TV docs			Magazine articles			Newspaper articles		
Type	N	NF	Type	N	NF	Type	N	NF	Type	N	NF
and	7,978	283.9	and	8,564	238.1	and	4,493	243.4	and	3,784	233.3
but	1,105	39.4	so	2,332	64.9	but	775	41.9	but	623	38.5
so	576	20.5	but	1,987	55.3	also	437	23.7	also	295	18.2
also	553	19.7	because	681	18.9	so	299	16.2	so	250	15.5
while	237	8.9	still	273	7.6	because	184	9.9	because	169	10.5
however	178	6.4	also	249	6.9	still	158	8.6	while	145	8.9
still	161	5.8	again	173	4.9	while	150	8.2	still	93	5.8
yet	142	5.1	yet	116	3.3	however	84	4.6	however	85	5.3
rather	136	4.9	since	103	2.9	yet	82	4.5	since	73	4.6
since	103	3.7	while	99	2.8	though	60	3.3	yet	50	3.1

Table 2

Frame markers

Books			TV docs			Magazine articles			Newspaper articles		
Type	N	NF	Type	N	NF	Type	N	NF	Type	N	NF
so	576	20.5	so	2,332	64.9	so	299	16.2	so	250	15.5
first	385	13.7	now	898	24.9	first	219	11.9	first	241	14.9
then	276	9.9	then	709	19.8	now	214	11.6	now	191	11.8
well	228	8.2	first	405	11.3	then	159	8.7	last	167	10.3
(in) part	187	6.7	well	392	10.9	well	141	7.7	then	124	7.7
now	165	5.9	Want to	212	5.9	(in) part	112	6.1	well	124	7.7
(in) chapter	162	5.8	last	196	5.5	last	67	3.7	next	107	6.6
second	130	4.7	(in) part	190	5.3	next	61	3.4	(in) part	90	5.4
next	86	3.1	next	186	5.2	(in) the x part	50	2.8	listing(a,b	81	4.9
last	80	2.9	back to	100	2.8	second	50	2.8	second	64	3.9

Table 3
Endophorics

Books			TV docs			Magazine articles			Newspaper articles		
Type	N	NF	Type	N	NF	Type	N	NF	Type	N	NF
Example	281	9.9	before	273	7.6	before	144	7.8	before	110	6.8
(in) part	187	6.7	(in) part	190	5.3	(in) part	112	6.1	(in) part	90	5.6
before	171	6.1	later	100	2.8	Example	75	4.1	Example	47	2.9
(in) chapter	162	5.8	above	67	1.9	later	63	3.5	above	42	2.6
Figure	117	4.2	Example	56	1.8	(in) the x part	50	2.8	later	39	2.5
later	102	3.7	Figure	54	1.5	above	27	1.5	earlier	32	1.9
Fig.	80	2.9	below	49	1.4	below	24	1.3	below	20	1.3
above	78	2.7	(in) the x part	38	1.1	earlier	22	1.2	(in) the x part	12	0.8
(in) the x chapter	50	1.8	Table	18	0.5	Figure	19	1	(in) section	8	0.5
(in) this chapter	38	1.4	(in) the x chapter	11	0.3	before	11	0.5	Figure	6	0.3

Table 4
Evidentials

Books			TV docs			Magazine articles			Newspaper articles		
Type	N	NF	Type	N	NF	Type	N	NF	Type	N	NF
(date)/(name)	726	25.9	(date)/(name)	150	4.2	(date)/(name)	150	8.2	(date)/(name)	178	10.9
(to) cite	6	0.3	(to) cite	-	-	(to) cite	1	0.06	(to) cite	1	0.07
(to) quote	8	0.3	(to) quote	1	0.03	(to) quote	1	0.06	(to) quote	-	-
[ref. no.]/[name]	16	0.6	[ref. no.]/[name]	-		[ref. no.]/[name]	-	-	[ref. no.]/[name]	-	-
according to	88	3.2	according to	11	0.4	according to	83	4.5	according to	99	6.3
cited	6	0.3	cited	-	-	cited	2	0.2	cited	2	0.2
quoted	6	0.3	quoted	-	-	quoted	-	-	quoted	3	0.2

Table 5
Code glosses

Books			TV docs			Magazine articles			Newspaper articles		
Type	N	NF	Type	N	NF	Type	N	NF	Type	N	NF
-	2,974	105.9	or	790	21.9	-	1,119	60.7	-	1,334	82.3
(…)	1,863	66.3	say	309	8.6	or	712	38.6	or	486	29.9
or	1,432	50.9	called	210	5.9	(…)	663	35.9	(…)	406	25.1
such as	351	12.5	that is	187	5.2	called	142	7.7	such as	108	6.7
for example	194	6.9	I mean	144	4.1	such as	139	7.6	say	99	6.2
called	167	5.9	in fact	60	1.7	say	104	5.7	called	92	5.7
that is	161	5.8	that means	46	1.3	for example	57	3.1	that is	69	4.3
say	98	3.5	for example	36	1.1	known as	56	3.1	known as	56	3.5
in fact	72	2.6	known as	35	1.1	that is	44	2.4	for example	32	1.9
known as	60	2.2	which means	22	0.7	for instance	31	1.7	for instance	12	0.8