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A Psycholinguistic Analysis of Students' Semantic Perceptions of Popular Science Texts in The Field of Natural Sciences: A Case Study at Toraighyrov University

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Abstract
The psychological aspects of the properties and relationships that emerge during text comprehension have primarily been studied from both subjective and objective viewpoints. This paper aims to explore the psychological factors influencing scientific text comprehension, focusing on the quantitative and qualitative patterns of how students perceive popular science information. The study employs various statistical methods to analyze patterns in how students interpret and evaluate popular science texts. The study comprehensively examines students' responses to popular science literature, highlighting the imperative to customize scientific presentations to the audience's preferences and cognitive capabilities. It posits that readability, comprehensibility, and engaging narrative styles are vital when addressing a general readership. The findings underscore that popular science is a significant medium for disseminating knowledge, extending

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beyond mere entertainment, with a primary goal of making complex scientific information accessible to a broader and more diverse audience. This research is especially pertinent given the growing interest in these writings, which effectively merge the intricate nature of scientific discourse with artistic elements to capture the attention and understanding of general readers.

Keywords: Feature-Correlation Analysis, Metatext, Popular Scientific Text, Psycholinguistic Phenomenon, Statistical Analysis.

Introduction

A popular science text is a type of educational material that combines different genres; although it may have a relatively simple and sometimes lightweight external form but quite complex in terms of content. This complexity of popular science texts is often associated with two things, viz., combination of genres, and the unique way in which the author structures the text. However, in a narrow sense, text comprehension can be viewed as a component of thinking, reflecting the fundamental properties and relationships between objects and events. Besides, there are various perspectives on the issue of text comprehension, each contributing to the understanding of how individuals interpret a popular science text. However, a common theme across these theories is the belief that prior knowledge plays a significant role in the process of understanding the text. This suggests that readers' background, experiences, and existing knowledge base build their conceptual framework, which helps organize and interpret the flow of information and influences their ability to grasp new information.

The readers' conceptual framework not only serves as a lens through which they perceive and organize incoming information or shape their understanding, but this framework also enables readers to connect new ideas to what they already know, facilitating deeper comprehension. Essentially, deeper understanding of the text is only one aspect, which is the most common aspect of thinking about formalized methods of organizing the text. However, this aspect is seen in a limited sense as it functions as a generalized and indirect reflection of fundamental categories of a text and their relationships that exist within the text. Therefore, as research moves towards more meaningful and a semantic structure of the text, individual types of texts become the focus of researchers' attention: viz., artistic, scientific, technical, popular, informative, and so on. For instance, the texts in a popular science category would bring scientific knowledge to a wide audience of readers who are not experts in a specific field of science. The informative texts would aim to introduce the general reader data through techniques of presenting knowledge and information.

In this context, a need was felt to conduct an experimental study to elucidate the validity or lack thereof of these categories in the text. There is a dearth of studies on the categorization of texts and the resultant criteria from these categories that would shape readers compressibility and knowledge levels, and make the relevant texts accessible to readers. For this purpose, the current study classified the sampled texts into five categories scientific vs. unscientific, popular vs. unpopular, fiction vs. non-fiction, interesting vs. uninteresting, and informative vs. uninformative. There is a lot of distinctiveness in these categories, a few are relatively clear-cut, others less definitive, existing implicitly rather than explicitly. The last category, for example, is often synonymous with cognitive versus unfathomable and useful versus futile. Typically, the assessment of a text in terms of the aforementioned criteria, particularly in the context of popular science and its appeal to the reader, is conducted on an intuitive level without considering the degree of reality of these criteria in the reader's perception or the prevalence of certain criteria when evaluating a piece of writing.

The current study attempts to investigate the psychological characteristics that influence students' understanding of popular science texts. Statistical methods were used to analyze both quantitative and qualitative patterns, aiming to uncover how students perceive and engage with popular science information. By examining these patterns, the research seeks to provide insights into the complexities of text comprehension and various factors that contribute to students' understanding of scientific concepts presented in accessible formats. This study's contribution to the field is its novel approach to addressing the complexities that arise within popular science texts, particularly in how these complexities shape students' perceptions and understanding at Toraighyrov University. This inquiry is grounded in experimental data that facilitates a deeper comprehension of the intricate relationship between students and popular science literature. Ultimately, the study enhances the discourse surrounding popular science by elucidating its complexities and examining its profound impact on student perceptions at Toraighyrov University.

Literature Review

The status of popular scientific writing is a subject of diverse perspectives among linguists (Desaire et al., 2023; Gvozdev, 1965; Rosenthal, 2001). Negretti, Persson, & Sjöberg-Hawke (2022) defines popular science as an independent genre; Grishechkina (2016) views it as a type of scientific style; Belas (2014), Troyanskaya (1982) and Tang (2022) call popular science as a subtype of a larger scientific style. This diversity of opinions

can be attributed to a lack of focus and the heterogeneity of functional styles as well as absence of comparative studies on popular scientific writing and its impact on language functions. The major objective of popular scientific writing is to facilitate the dissemination of scientific knowledge so that it can be enjoyed by general public (Firmansyah, Al Habib, & Prihandini, 2023). Very few linguists have devoted themselves to the task of popularizing scientific advancements, despite recognizing the importance of such endeavors. For the advancement of society, it becomes crucial to focus on the study of accessible scientific linguistic literature. Alvim da Silva et al., argue that it is not enough for scientists to merely convey scientific knowledge (Alvim da Silva, Pereira, & Felizardo, 2022). Popular science writing has the potential to be an effective tool for improving student attitudes toward science and increasing student engagement with science in an introductory general education science course (Lewis et al., 2023).

The popular science text is characterized by its distinct features in terms of linguistic forms, their development, and usage. It exhibits specific attributes of presentation, including impartiality, autonomy, and originality, which serve as the primary criteria identified by Serdobintseva (2012) and Bolshakova (2023). When scientific correspondence between the most learned Europeans was integrated into the educational process in the 17th century, the first instances of science popularization were found (Sokolova & Zabolotskikh, 2023). In recent years there has been a surge of groundbreaking artworks at the intersection between art and science, many of which are fruits of cross-disciplinary collaborations (Gewin, 2021). Scientific ideas inspire these artworks and use science and technology as a medium (Segal & Meroz, 2023). The number of artistic and scientific collaborations in a variety of settings and types of contact has steadily increased over the past 20 years (Jung et al., 2022). As a result, new artistic trends have been developed from close relationship between the artist and scientific progress (Liu & Li, 2023). The authors of popular science text now rely on scientific findings they wish to share with their audience, for which they strive to find an artistic medium to convey these ideas, transcending the boundaries of the scientific style.

Popular scientific writing thus became the vehicle to explore the intricacies of language functioning beyond what intuitive analysis permits (Baudouin de Courtenay, 1965; Shcherba, 1974). These writings provided semantic perception of subjects with linguistic signs which most readers may often be unaware of (Ayudhya, 2021). This underscores the need to develop a scientific and an experimental mindset that allows readers to understand their semantic perceptions. However, an objective challenge to achieving a comprehensive understanding and investigation of all stages and aspects of semantic perception lies in the multilevel nature of this process and the obscured nature of its trajectory. The implicit characteristics of speech and cognitive processes necessitate the implementation of experimental studies that can elucidate the analyzed components within this process (Dridze, 1994).

Numerous psycholinguists, both domestic and international, are investigating methods to experimentally analyze the processes involved in the generation and perception of semantic messages (Adamou, 2021; Asrifan, Karinda, & Buhari, 2022; Duñabeitia et al., 2022; Koizumi, 2022), establishing methodologies for experimental research (Alduais et al., 2022; Hinojosa, Moreno, & Ferré, 2020; Tim & French, 2021) and establishing essential groundwork for experimental psycholinguistic inquiry (Alfrey et al., 2021; Fischer, Engelhardt, & Herbelot, 2022). In an seminar study, Belyanin (1983) had examined and analyzed through an experiment employing the semantic method on the material of science fiction texts (159 subjects, 4,010 responses). This experiment allowed him to identify some features of how science fiction texts are perceived, related to their specific verbal and conceptual structures. Based on the results of a complex psycholinguistic experiment using a psycho-diagnostic questionnaire (99 participants, 28,413 responses), he concluded there exists a relationship between the semantic perception of texts and personal linguistic awareness of readers.

Contemporary popular science authors, therefore, particularize the world and give it a human perspective, thus employing scientific disciplines to semiotize the world through scientific generalizations about objects and processes (Virtanen, 2022). Al Darwesh (2024) states that “Popular science books are still the primary medium for promoting science to the public as an epistemic way to understanding and being aware of our natural world”. A good example is a recent study (Sauppe, Andrews, & Norcliffe, 2023) which delineates the core aspects of an information-oriented approach, wherein a text is viewed as a hierarchy of communicative programs, with their effectiveness ascertainable solely through psycholinguistic experimentation. Similarly, Torubarova’s psycholinguistic experiment (2024) also explores the processes of perception, comprehension, and production of scientific texts by students at a medical university.

Methodology

Research Design

This study adopted a quantitative research design with participant-centered experimental approach, to study the psychological aspects and semantic perceptions of readers that emerge during text comprehension. This research design enabled exploring not only the psychological factors influencing scientific text comprehension, but also helped focus on the quantitative patterns of students’ perceptions about popular scientific writings.

Data Collection Instrument and Procedure

The study used the Reliability Coefficient (HRC) and Validity Coefficient Metrics to understand the intricate nature of scientific discourse and capture the attention and understanding of general readers. The Reliability Coefficient (HRC) method requires dividing the assessment sample into two groups, one containing odd numbers (1, 3, 5, and so on) and the other containing even numbers (2, 4, 6, and so forth). After calculating the scores of each group and presenting them in distinct tables, two rankings are assigned to each participant, one based on the performance of the odd group and the other based on that of the even group. The following formula is utilized to calculate the correlation coefficient p between the two sets of rankings:

$$p = 1 - (6 \sum d2 \, N(N2 - 1))$$

In this equation, d represents the difference between the ranks assigned to each participant in the two groups, while N signifies the total number of participants involved in the assessment. The resulting correlation coefficient p serves as a statistical measure of the relationship between the two sets of rankings, providing important insights into the reliability of the test. This coefficient is particularly beneficial when determining the reliability of a test that has been extended to twice its original length. To arrive at the overall reliability of the HRC test, one can utilize the subsequent equation:

$$HRC = \frac{2rhh}{1 + rhh}$$

In this formula, HRC represents the reliability measure, while the Spearman–Brown coefficient is a specific method for estimating reliability. By carefully following these steps and calculating the relevant statistical metrics, one can effectively assess the reliability level of a test designed to measure comprehension of popular science texts.

Next, to calculate the validity coefficient, one must measure the correlation between two datasets that represent different aspects of the construct being assessed. Once the correlation is established, the coefficient is squared to produce a validity metrics. This validity metrics indicates how effectively the test evaluates the intended comprehension proficiency, ultimately assisting educators and test developers in refining their assessments to achieve desired outcomes.

Sampling

Three scientifically inclined texts of approximately equal length, were selected from highly rated popular writings, followed by their evaluation of each text for the following characteristics: whether it is scientific or unscientific, popular or unpopular, fiction or non-fiction, interesting or uninteresting, and informative or uninformative. Twenty-five students from the Humanities and Social Science faculty of Toraighyrov University were tasked with providing both positive and negative assessments for each pair of characteristics. The time given for identifying these features was unlimited, and almost all participants completed the task within 25–30 minutes.

Data Analysis

The study employed various statistical methods to analyze patterns in how students interpret and evaluate popular scientific texts. Using the traditional post-test analysis methods, different statistical metrics were used to analyze the effectiveness of testing procedures as well as the metrics obtained through reliability and validity tests. The reliability test refers to the consistency of scores obtained through a test, indicating whether a particular individual would produce similar results if they took the test again in a short period without additional language training. A reliable test would produce similar outcomes when administered twice under similar conditions. While conducting the statistical analysis, we drew upon the materials presented in the research. Statistical analysis of the experimental data was also conducted using the X^2 test. To evaluate the second critical aspect of validity, the test measures of all concepts or constructs were accumulated. For example, the validity measures of constructs like psychological comprehension and semantic perception of popular scientific texts were analyzed for determining the extent to which the authors of the text clarify their intentions and offer insights to facilitate the assessment.

Results and Findings

Twenty-five students from the Humanities and Social Science faculty of Toraighyrov University were tasked with describing the following characteristics of a text: whether it is scientific or unscientific, popular or unpopular, fiction or non-fiction, interesting or uninteresting, and informative or uninformative. The students were asked to provide both positive and negative assessments for each characteristic. The time given for identifying these features was unlimited, and almost all participants completed the task within 25–30 minutes. Of the twenty-five students, twelve described the features exclusively in positive terms, such as scientifically, popularly, artistically, and informatively. One student, who described the features positively,

also provided a negative assessment of the feature as not being interesting. Another student, in addition to describing the features positively, described them as unscientific, unpopular, and non-fiction. A single student provided both positive and negative definitions for the characteristics. The remaining ten participants offered the following interpretations: three participants characterized three attributes positively (scientific, popular, and interesting), while two others did so negatively (non-fiction and uninformative). Two subjects identified three positive attributes (popular, interesting, and informative) as well as two negative attributes (unscientific and nonfiction).

Two other participants identified four positive attributes (scientific, popular, fiction and informative), with one negative attribute being uninteresting. Three other participants identified four positive aspects (popular, fiction, interesting, and informative), but one negative aspect was deemed unscientific. Finally, one participant identified four positive qualities (scientific, popular, interesting, informative) and one negative quality as non-fiction. Finally, one subject has identified two positive aspects (popular and interesting) as well as three negative aspects (unscientific, non-fiction, and uninformative) of the given text.

Text Perception: Experimental Assessment Employing Feature-correlation Analysis

The methodology of the experiment involved presenting subjects with three texts of approximately equal length, followed by their evaluation of each text on a scale for each pair of features. It was hypothesized that this scale would serve as a tool for determining the degree of correlation between the object (the text) and a particular feature in all five categories, viz., scientific vs. unscientific, popular vs. unpopular, fiction vs. non-fiction, interesting vs. uninteresting, and informative vs. uninformative. If subjects found it challenging to establish a correlation, they were instructed to enter a 0 into the response matrix. Alternatively, they were asked to enter -3, -2, and -1 to denote the negative degree of correlation, where -3 represented the highest degree, with the sign indicating an unscientific or unpopular correlation. Conversely, 3, 2, and 1 were entered to indicate positive degrees of correlation that were associated with a scientific or popular fiction, or any other positive connotation. Table 1 presents the series provided to the participants to enter the scores for each feature or category of scientific writings.

Table 1: *Correlation Scores Used for Evaluation.*

Category/ Negative Correlation	**No correlation**	**Category/ Positive Correlation**
-3 -2 -1	← 0 →	1 2 3
Unscientific		Scientific
Unpopular		Popular
Non-Fiction		Fiction
Uninteresting		Interesting
Uninformative		Informative

Three scientifically inclined texts were selected from highly rated popular writings. The first text was an extract from a scholarly article “Genetic Regulation of Protein Synthesis" by Jacob, and Monod (1961), comprising 1,032 characters excluding spaces. This article explored the question of how DNA stores genetic information, emerging from an examination of its chemical structure. DNA is a polymer composed of deoxyribonucleotides connected by phosphate bridges that link the deoxyribose residues of each nucleotide to form the backbone of the carbohydrate-phosphate molecule. The side groups in this chain are composed of purine and pyrimidine bases.

The second text was a section from a popular scientific book by Dubinin and Gubarev (1968) entitled *The Thread of Life*. The book provides a comprehensive exploration of fundamental principles of life and delves into the intricate operations of biological systems, providing a profound understanding of the mechanisms governing the existence and evolution of living organisms. The DNA molecule is a likely information carrier due to its sequence of purines and pyrimidines. This is the only topological characteristic of its "primary" covalent structure. Knowledge of the three-dimensional structure of DNA supports this view further. According to the Watson-Crick model, DNA consists of two intertwined strands held together by specific hydrogen bonds between base pairs. Adenine (A) pairs with thymine (T), and guanine (G) pairs with cytosine (C), in a complementary manner. From a chemical perspective, DNA is a relatively simple compound. It consists of remnants of sugar molecules (deoxyribose) and phosphoric acid, to which four distinct nitrogenous bases are attached. These bases are essentially identical in all life forms, including viruses and humans. American scientist James Watson and his British colleague Francis Crick, who were jointly awarded the Nobel Prize in 1962 for their seminal work on elucidating the structure of DNA, have demonstrated that this molecule consists of a long chain composed of alternating sugar and phosphate units. To this backbone, purine bases such as adenine and guanine and pyrimidine bases including cytosine and thymine are linked as functional groups. Following the established structure, the DNA molecule forms a twisted and coiled helical structure. This structure consists of two polynucleotide chains, which are linked together by chemical bonds, effectively binding the two strands into a single entity. These bonds, formed by pairs of nitrogen-containing bases connected by hydrogen bonds, are located within the interior of the helix, similar to the steps on a

ladder. This large "corkscrew" with crossbars demonstrates remarkable stability due to its three-dimensional structure. The helical shape is formed from strong materials, specifically designed from substances that have chemical resistance;

The third text was a science fiction narrative, *The Lymphatic Formula,* wherein the author, Lem (1968) offers a glimpse into the extraordinary. The author devises a method for creating large protein molecules, which can come to life in the form of artificial protein solutions resembling viscous jelly. These creatures are cherished by the author, who provides them with nourishment daily, feeding them sugar and hydrocarbons. The evolution of these creatures is fascinating, from small Petri dishes to larger containers, and the entire laboratory is filled with them. However, some of them perish due to improper diet, leading the author to become irate and frustrated. Despite his efforts, he does not achieve further success, possibly due to his lack of expertise in conducting more research.

Utilizing the X^2 Test for statistical analysis of all three texts, variance and deviation were measured. The results are presented in Tables 2, 3, and 4, where where (+) indicates that distinction occurs, while (—) shows no distinction.

Table 2: *Text Scores including Variance and Deviation (Text 1).*

Variance (δ)	0	X^2	+/–	Deviation (σ)	Variance (δ)	X^2	+/–
25	–	$\frac{(25-0)^2}{25}=25$	+	–	25	$\frac{(25-0)^2}{25}=25$	+
24	1	$\frac{(24-1)^2}{25}=21{,}1$	+	17	7	$\frac{(17-7)^2}{24}=4{,}1$	+
20	5	$\frac{(20-5)^2}{25}=5$	+	15	5	$\frac{(15-5)^2}{20}=5$	+
25	–	$\frac{(25-0)^2}{25}=25$	+	8	17	$\frac{(8-17)^2}{25}=3{,}2$	+
25	–	$\frac{(25-0)^2}{25}=25$	+	1	24	$\frac{(1-24)^2}{25}=21{,}1$	+

Table 3: *Statistical Comparison of Text Scores for Various Text Types with Variance* ***(δ)*** *and Deviation* ***(σ)*** *(Text 2).*

Variance (δ)	0	X^2	+/–	Deviation (σ)	Variance (δ)	X^2	+/–
23	2	$\frac{(23-2)^2}{25}=17.6$	+	1	22	$\frac{(1-22)^2}{23}=14.7$	+
25	–	$\frac{(25-0)^2}{25}=25$	+	5	20	$\frac{(20-5)^2}{25}=5$	+
21	4	$\frac{(21-4)^2}{25}=11.5$	+	9	12	$\frac{(9-12)^2}{21}=\frac{9}{21}$	–
24	1	$\frac{(24-1)^2}{25}=21.1$	+	4	20	$\frac{(4-20)^2}{24}=10.6$	+
25	–	$\frac{(25-0)^2}{25}=25$	+	1	24	$\frac{(24-2)^2}{25}=21.1$	+

Table 4: *Metrics of Variance and Deviation in Text Study (Text 3).*

Variance (δ)	0	X^2	+/–	Deviation (σ)	Variance (δ)	X^2	+/–
23	2	$\frac{(23-2)^2}{25}=17.6$	+	17	6	$\frac{(17-6)^2}{23}=5.2$	+
25	–	$\frac{(25-0)^2}{25}=25$	+	6	19	$\frac{(6-19)^2}{25}=6.7$	+
24	1	$\frac{(24-1)^2}{25}=21.1$	+	9	15	$\frac{(9-15)^2}{24}=\frac{36}{24}$	–
24	1	$\frac{(24-1)^2}{25}=21.1$	+	9	15	$\frac{(9-15)^2}{24}=\frac{36}{24}$	–
21	4	$\frac{(21-4)^2}{25}=11.5$	+	16	5	$\frac{(16-5)^2}{21}=5.7$	+

Given that the subjects have indicated the “degree of connectedness” with a sign, it is not only possible to identify those signs that were noted by the statistical majority of participants, but also to calculate the “degree of relatedness” (θ) with which this was done. Table 4 presents attributes based on the values of θ

$$\theta = \frac{1*n_1+2*n_2+3*n_3}{n_1+n_2+n_3},$$

where n_i represents the number of attributes assigned to the feature.

Evaluating Text Features and Reader Involvement Via Quantitative Analysis

For scientific writings, fiction, the five pair of criteria included scientific — unscientific, popular — unpopular, fiction — non-fiction, and informative — uninformative. The results of the experiment as presented in Table 5 show that the relevant criteria for each scientific text had a particular significance, which suggests that characteristics of each of these criteria can be attributed to any piece of writing.

Table 5: *Category-averaged Scores for Text Features.*

Category/ Criteria	1	2	3
Unscientific			2.70
Scientific	2.52	2.09	0
Unpopular		2.05	2.31
Popular	2.29	0	0
Non-Fiction		2.24	2.74
Fiction	2.94		
Uninteresting	2.64		
Interesting		2.05	2.43
Uninformative	2.41	2.08	
Informative	0	0	0

The findings show the extent to which each of these characteristics can be quantified, offering valuable insights into its nature. For the third text under analysis, which falls within the genre of science fiction, the attribution for scientific and non-scientific characteristics amounts to 0 and 2.70 respectively. The text under consideration exhibits a strong scientific bias, yet it also incorporates elements that are not typically associated with scientific discourse. In contrast, the first and second texts demonstrate a complete absence of scientific attribution, suggesting a focus on popular appeal or informational value rather than a distinct scientific or non-scientific orientation

The level of popular appeal of the first text is estimated at 2.29, while the second and third texts both register a score of zero, indicating that the former may be more widely appealing, while the latter may be more specialized. Moreover, the informational content of the first text appears to be meager, with a score of zero. The remaining two texts also receive a score of zero, suggesting that they may not provide substantial new insights. Regarding the fiction attribute, the first text displays a non-zero score of 2.94, whereas the other two texts receive a score of zero. It is noteworthy that all three texts exhibit a degree of apathy, indicating a certain level of engagement. The second text exhibits a level of interest equal to 2.05, whereas the first and third texts register zero. In terms of content that lacks informative value, the third text receives a score of 2.43, whereas the first and second texts are both assigned a value of zero. Moreover, the level of informativeness of the texts is evaluated at 2.41 for the first text, 2.08 for the second text, and zero for the third text. The first concept relates to the informational content of a text, which can be conceptualized as a compilation of meanings designed to represent and interpret diverse objects, phenomena, and processes for the reader. From a psychological standpoint, these meanings can be understood as methods through which readers interact with the text, actively participating in the reading process.

Analyzing the Meaning of Metatext and Attributing Elements in Popular and Scientific Science Texts

In designing the experiment, three hypotheses were formulated that required verification:

1. that texts can be evaluated based on signs that emerge in metatextual discussions on specific principles of text organization and functioning;
2. that five proposed binary features are pertinent for text consumers and serve as criteria for evaluating texts, particularly popular science texts;
3. that it was necessary to ascertain which of these features corresponded to each of the texts proposed in the experiment and to what degree.

These hypotheses were tested on the realm of information inherent in a text and the text itself as a linguistic entity not being synonymous. While the text, constituted by a collection of linguistic signs, constitutes a linguistic phenomenon, the realm of information surrounding the text emerges as a psycholinguistic phenomenon. The findings of the experiment corroborated the hypothesis that texts are indeed assessed based on the characteristics inherent in metatextual elements. However, the interplay between these features and their meaningful attribution to a given text is a variable factor.

The first scientific text exhibits several distinctive features. It is void of any fiction elements and devoid of the allure that is often associated with popular writing. Nonetheless, it serves as a reliable source of information. Evaluating this text is not contingent upon the criterion of whether it is deemed interesting or not. In other words, in the realm of scientific discourse, certain attributes that may serve as markers of linguistic and conceptual diversity appear to be inconsequential. In contrast, the second text is characterized by its scientific, populist, and engaging nature, coupled with its informative content. The presence or absence

of fiction elements is not a determining factor in assessing the quality of the text. Consequently, it can be deduced that both scientific and popular science texts are expected to impart information that is either of a practical or a theoretical nature. Nonetheless, this text presents an intriguing aspect that contrasts with the non-fictional element present in the preceding text. All other characteristics assigned to both texts by their respective subjects either overlap or are mutually exclusive, thus establishing a clear distinction between the two textual genres. Science fiction, the third type of text, is characterized by non-scientific and popular elements. It provides information, but lacks fiction aspects and may not appeal to all readers.

Vrba & Sofian (2024), for example, observed that scientific prose from the 19th century exhibits certain distinctive features. Any deviation from informational uniformity within a text can serve as an indication that it belongs to a distinct genre. The heterogeneity of information in a text often serves as a marker of fiction, the greater the heterogeneity, the more likely readers are to categorize the text as belonging to a specific genre such as scientific, popular scientific, or speculative fiction (or even literature). Hence, there is a similarity between the second and third types of texts based on their popular elements. However, the remaining features of the popular scientific text contrast with those found in the scientific or popular scientific text. It is possible to assume that the shared popular element between the two types of texts also represents a shared informational content, which the reader perceives in the second and popular scientific texts against the background of contrasting features.

The characteristics of the third text, in turn, are in stark contrast to those of the first, except for those aspects that are irrelevant to the comparative analysis of both texts. This divergence suggests that we are dealing with distinct pieces of information concerning one another. The features of the second text, as outlined above in terms of their interrelationships, either align with or contradict those of the first, indicating a degree of informational correspondence or dissimilarity between these two texts based on shared or conflicting characteristics. This realm encapsulates how the meaning of linguistic signs is perceived by the reader, as depicted in Table 6 (where a positive (+) denotes a characteristic associated with the text, and a negative (-) denotes a characteristic contrary to the text).

Table 6: *Evaluating Textual Components across Multiple Domains*

Category/ Criteria	1	2	3
Scientific	+	+	2.70
Unscientific			–
Popular		+	+
Unpopular	–		
Fiction	–		
Non-Fiction	–		
Interesting		+	
Uninteresting			
Informative	+	+	+
Uninformative			

In terms of content, the evaluation criteria for the texts were four for the first two texts and three for the third one. It is worth noting that the second text, a popular science article, stands out with its exclusively positive features. If we interpret negative aspects as extraneous to the text and allow their presence without affecting its functionality, we can view the second text as a harmonious unity of positive features that enable its operation. In other words, non-fiction texts aimed at a wide audience do not preclude the incorporation of diverse structures, which complicates their production. Crafting such texts entails discerning how various social groups perceive and interpret the characteristics of the textual material.

Popular Science: Structural Variability and Semantic Demystification

Analyzing the semantic content of scientific and non-technical symbols reveals that popular science writing emerges as a harmonious fusion of heterogeneous informational structures, integrating scientific, colloquial, and fiction elements. The dissection of the constituent parts of symbolic meaning, both scientifically and colloquially, further elucidates that the essence of popular science lies in the audience's comprehension of the concept of demystification. This demystification is not confined to an international or intra-scientific context but rather assumes a broader educational perspective. The functioning of a popular science text as a complex of heterogeneous informational structures, characterized by the presence of scientific, populist, and fictional components, is in line with the ideas put forward by Ivanov (2015) and Mykhalchuk et al. (2021) regarding the mechanisms of poetic language.

If we assume that the entropy of language (H) can be divided into two components: semantic capacity (h_1), which represents the language's ability to convey specific semantic information in a text, and flexibility (h_2), which denotes the capacity to express the same content through various means, we can explore how a popular science text operates $h_1=h_2$. Then, the scientific text is at h1, and the popular scientific text is at h2. (Lexico-stylistic and syntactic restrictions imposed on scientific and popular scientific texts are not taken

into account in this case, as this issue requires further research.) Calculations of the mathematical distance between the texts also show this to be true (the calculations were based on the results of the first experiment).

The text was considered a point in an n-dimensional space (n=5), with coordinates determined by the features used to evaluate the text. The distance was calculated using a formula:

$$D\ (x, y) = \sqrt{\sum_1^n d}\ (x_i, y_{i)}{}^2$$

The distance function *D (x, y)* denotes the separation between two points, which represent the semantic meanings of texts based on a set of five criteria (x, y). The difference in coordinates of feature i.e., denoted as $d\ (x_1, y_1)$, is calculated for each feature, and a summation is taken over all features.

The mathematical analysis reveals that the distance between scientific and popular scientific texts is approximately – ≈3.46. The separation between scientific texts and popular scientific texts amounts to approximately – ≈ 6.99, while the gap between scientific and popular scientific texts is approximately – ≈ 4.98. These results support the hypothesis that popular scientific content encompasses a diverse range of information structures. It would seem that such a structure for a popular science text is effective only for those texts that fall under the general educational form of popularization. However, texts related to international and/or academic popularization may have different expectations from their audience, depending on the specific orientation of the text. Consequently, the criteria for evaluating such texts, as well as the significance of those criteria, may vary.

At this point, it is only possible to speculate about the specific features that could be used to evaluate such texts in the context of both intra-scientific and international academic popularization. It seems likely that the translation of a system of concepts from one language into another and the adaptation of vastly different concepts within the same scientific discipline could initially rely on the principles of general educational popularization, resulting in a text that retains the characteristics of that form of popularization. At this point, a scholar will acquire a new scientific language, which will enable them to become a true polymath of science. As they delve into this second language, they will be able to navigate and comprehend a new field of study.

Discussion

The text can be scientifically interpreted in the following way: it is presented with the most recent scientific data and is accessible to readers who have a certain background in a particular field of knowledge. The concepts and terms used in the text are understandable to specialists in this field. Only reliable facts are presented, or a hypothesis is formulated at a high level of abstraction. The texts sampled for the study engage and captivate many readers regardless of their field of expertise or educational background, making it a valuable resource for everyone. These texts contain such scientifically proven statements that are logically confirmed through experiments. If a reader attributes its content in a non-scientific manner, namely, based on their subjective reasoning, it will not be deemed to have been validated through empirical testing and will remain unsupported. Nonetheless, if past experiences are taken into consideration, the data shall fail to constitute a coherent framework. The sign is perceived by individuals as a characteristic of a text that appeals to the majority and caters to the needs of the general public. Complex concepts, facts, and empirical data are presented in a manner that is not only comprehensible to specialists but also accessible to the general audience.

The text thus serves as a vehicle for explaining scientific theories, employing analogies, metaphors, and imagery to elucidate complex concepts. The writing style is characterized by a sense of fascination that draws readers in, and is commonly associated with accessibility, usability, and widespread appeal, making it popular among a broad audience. However, some perceive the writing style of a scientific text as inaccessible to those unfamiliar with the subject matter and lacking in emotional impact. The texts chosen for this study elucidate specific facts and data in a manner that renders them comprehensible and imbued with a distinct authorial perspective. In metatextual discussions on the functioning of the given text, the pertinent indicators were characterized in a favorable light, with the descriptions themselves exhibiting certain distinctive features. The essence of science can be elucidated as follows: it is a process of discerning the objective essence of objects and phenomena in their interconnectedness, irrespective of personal perspectives. Science involves engaging in the advancement of scholarly thought by employing pre-established constants.

The findings of the study are evidence of the fact that scientific discourse lies in the realm of generalization and abstraction. The scientific discourse should be devoid of bias, impartial, and free from personal prejudices. It must adhere to strict standards, characterized by the meticulous use of specific terms and words related to the subject matter at hand. Scientific discourse exhibits an impersonal and monological nature, ensuring coherence and completeness in conveying information. This language is devoid of emotional attachments and intellectual. The sign may be construed as follows: an accessible text employs fiction imagery, tropes, and figures of speech. It is lucid and well-detailed, with general propositions elucidated

through specific instances. The text underscores the trajectory of logical reasoning and eschews technical terms or elucidations of their meanings. An accessible text contains a minimal number of facts, with some non-scientific content. It engages the reader's attention and furnishes original and unorthodox information. It disseminates scientific advancements among non-experts, providing genuinely scientific insights into nature and society.

The concept of informativeness, often referred to as "informational," was understood as being specific, concise, and purpose-driven in nature. An informative text, or informational text, does not cater to the general intellectual curiosity of the reader; it does not challenge our preconceived notions and requires no further elucidation. The text is concise and evocative, characterized by figurative language, unconventional comparisons, and emotive assessments. It provides answers to the questions of “who”, “what”, “where”, “when”, and “why”. Its informativeness is rooted in the inclusion of specific details, particulars, and minutiae, creating a pyramid of information with a pinnacle at the top. The text is succinct, precise, engaging, catchy, and tailored to the interests of the reader. Rather than merely recounting events, it delves into the core issue. Moreover, it demonstrates a profound comprehension of the central idea of the text. The interpretation of symbols by individuals diverges from that presented in metatextual analysis. In metatext, symbols are typically construed in a neutral or favorable light, whereas individual interpretations can be more optimistic or pessimistic. This divergence in interpretation may stem from differing perspectives and attitudes within the two groups engaged in the analysis process. The authors of metatexts tend to adopt a more imaginative approach, seeking to comprehend and appreciate a text and elucidate its structure and purpose, employing concepts with a greater capacity for interpretation.

The attitude of the second group of participants can be characterized as receptive. Members of this cohort employ both affirmative and negative modes of interpretation when analyzing the signs within the text. This stems from their lack of focus on explicating the structure and function of the text, allowing them to utilize positive and/or negative modalities for operational purposes. This group may rely on a standardized abstract text as the foundation for their analysis, enabling them to categorize the text according to specific criteria. The process of comparing the interpretations of symbols between our two groups entails determining the minimal number of elements that contribute to the overall meaning of these symbols. This analysis involves identifying these elements in both affirmative and negative interpretations provided by the members of each group and the authors of the metatext. For both groups, the constituents of a metatexts can be scientifically delineated as something that is correlated with data in a particular domain of expertise. They are specific, abstract, grounded in evidence, logical, and unequivocal. On the other hand, the components of an attribute can be commonly defined as something that correlates with data in some domain of knowledge, but they are not specific. They are publicly accessible and exist in some form of artistic expression.

Finally, the constituents of a feature may be artistically described as something that embodies individuality, metaphorically, association, sentiment, and aesthetic appeal, and carries multiple layers of meaning. Due to the inherent inconsistencies in the definitions offered by various subjects and authors in meta-textual contexts, it is challenging to provide a clear and comprehensive definition of these constituents. This difficulty is likely attributable to the fluid and dynamic nature of the semantic components of these features. The evolving value of these features allows recipients to engage with a diverse range of interpretations until they reach a state of relative stability. Another significant aspect is that this characteristic can be combined with an informational trait, enabling recipients to interpret these signals in diverse ways. A widely read text possesses varying artistic demands, contingent upon the comprehension of the fiction concept. For the audience, the fiction elements of the text manifest as a collection of specific stylistic devices. For those creating meta-textual commentary, fiction aspects exist in a more abstract form, defined by the subjective perspective of the individual author. The texts, designed for their ideographic purpose, remain neutral in terms of their impact on these processes and the intended audience.

Conclusion

Based on the comprehensive findings of our research, we can draw several nuanced conclusions regarding popular scientific texts:

1. Reader-Centric Evaluation: When assessing texts aimed at a popular scientific audience, it is essential to prioritize the needs and preferences of the readers. This approach highlights the critical role of readability, accessibility, and an engaging writing style. These elements work together to ensure that complex scientific ideas are not only understood but also resonate with a broad audience
2. Diverse Informational Structures: Publications within the realm of popular science present a unique opportunity to utilize an array of informational structures. This flexibility enables authors to present intricate scientific concepts in various formats, such as narratives, illustrations, or interactive elements. Such diversity caters to different learning styles, ensuring that individual preferences are met, and making scientific knowledge more digestible.

3. Educational Dissemination: Both readers and authors view popular science as a vital medium for wide-ranging educational dissemination. This perspective indicates that the purpose of these texts transcends mere entertainment; rather, it embraces a broader mission of imparting valuable knowledge. Popular science serves as a bridge connecting scientific advancements with the general public, fostering understanding and appreciation of scientific inquiry.
4. Customization of Presentation: The success of a popular scientific text is largely contingent on the author's ability to identify and emphasize aspects that resonate distinctly with specific readers. Understanding how they interpret these elements is fundamental. This insight underscores the importance of customizing the presentation of scientific data to suit the unique preferences and cognitive abilities of the target audience. Such customization enhances engagement and comprehension.
5. Relevant Textual Characteristics: The results of our experiment indicate that the pertinent characteristics of a scientific text can be categorized along several axes: scientific versus unscientific, popular versus unpopular, fiction versus non-fiction, and informative versus uninformative. These dimensions help in forming a nuanced understanding of how scientific literature is classified and perceived.
6. Semantic Distinction Measurement: The distance function D (x, y) serves as a tool for quantifying semantic distinctions between different types of texts by using five established criteria. This function specifically focuses on differences in coordinates within the text. Our analysis reveals that the distance between scientific texts and popular science texts is approximately 3.46, accompanied by a separation metric of 6.99 and a gap value of 4.98. These metrics illustrate the diverse structural characteristics inherent in popular science texts. While they are effective for general educational purposes, it is essential to acknowledge that texts intended for international or academic audiences may require alternative evaluation criteria to ensure they meet their specific communicative needs.

There is currently a limited amount of research available on this specific topic, which has led us to create new typologies to categorize statistical research more effectively. During our investigation, we identified several key limitations that merit attention. First, there are notable gaps in the existing scientific literature, indicating that foundational knowledge in this area is not well-established. Additionally, we found a significant lack of empirical research that employs statistical analyses, which hampers our understanding of the subject matter. Furthermore, there is a clear need for further development and exploration in this field to address these deficiencies and to advance our collective knowledge.

For the recommendations of the study, the analysis allows us to think about certain applications and insights regarding improving our understanding of teaching tactics. For instance, it is imperative to developing likeness for popular science text among students and increase their understanding through information accessibility. Secondly, it is necessary to provide psycholinguistic insight-based guidelines for teaching popular science texts in the natural science. Finally, psycholinguistic analysis methods should be adopted in universities and educational institutions to teach popular scientific texts. Overall, each of these recommendations focuses on the study's findings about how semantic perceptions affect comprehension which would help teachers or curriculum developers enhance material presentation or teaching methods in natural science education.

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