THEORY-CONSTITUTIVE METAPHORS, SIMILES, AND SCIENTISTS' NARRATIVES ABOUT THEIR TRAVEL AND/OR RESEARCH EXPERIENCE IN POPULAR SCIENCE ARTICLES/ EXAMINING LINGUISTIC AND RHETORICAL FEATURES

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Abstract: Among popular science publications, the most common type is the Popular Science Article (PSA). The main purpose of PSAs is to convey the necessary scientific content in the form accessible to non-specialists. They also contain the authors' personal evaluations, opinions and interpretations of the things related to their subject. This dissertation project is aimed at investigating the use of theory-constitutive metaphors, similes and scientists' narratives about their travel/research experience in the text of PSAs magazines intended for different categories of non-specialist audiences. Its results show that introducing these linguistic and rhetorical devices into the texts of PSAs may help their authors make communication between specialists and lay readers more effective. For example, the use of metaphors and similes which serve to link an unknown phenomenon or concept to a more familiar one by comparing them allows the authors of PSAs to make complex concepts graspable, simple, and thus comprehensible for the general public. At the same time, including the narratives about scientists' travel and/or research experience in the texts of PSAs allows their authors to balance their dual goals of reporting objective and accurate factual and scientific information, on the one hand, and conveying the researchers' and the authors' personal evaluations and opinions, on the other hand. Including additional clues (evaluative adjectives, lexical intensifiers and mitigating devices, etc.) in the similes and narratives employed in PSAs enable their authors to convey the necessary scientific content in a vivid and engaging way. It also follows from the findings that the use of these devices in the text of PSAs is characterized by certain common and varying features. This refers to the frequency and ways of using theory-constitutive metaphor and simile in the text of PSAs as well as the communicative and pragmatic purposes of scientists' narratives about their travel/research experience. Variations observed in the use of the above-mentioned linguistic and rhetorical means point to the fact that the subject of the articles, their target audience and specific purposes of the magazine where they are published need to be regarded as the contextual factors affecting their use in the text of PSAs.

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CHAPTER I.

INTRODUCTION

Popular science communication (that is, communication between the specialists in a certain area of studies and the general public) is aimed at conveying scientific ideas, findings and discoveries to non-specialist audiences. This serves as a bridge between scientific literature as a professional medium of scientific research, and the realms of popular political and cultural discourse. Popular science publications perform different socio-cultural functions. First of all, they attempt to inform and convince scientific outsiders (sometimes along with specialists in other fields) of the significance of data and conclusions and to celebrate the results of research (Fahnestock, 1986). In addition, popular science texts report on propositions before they are accepted and endorsed as fact by the research community, that is before they become authoritative (Parkinson & Adendorff, 2004). They also give voice to scientists other than those of iconic status (Lemke, 1990).

At the same time, communication between scientists/scholars and non-specialist audiences actually takes place through different kinds of popular science publications. In its turn, sharing new knowledge with scientific outsiders and specialists in other areas of science contributes to the further development of science education and the interrelations between different fields of study (Parkinson, 2000). In this connection, it is logical to assume that popular science texts created for the purpose of large-scale dissemination and popularization of scientific

knowledge begin to play even a more important role in the global dialogue between the representatives of different disciplines and the general public.

The growing importance of popular science publications led to the necessity of conducting research on various linguistic, pragmatic and rhetorical features that make communication between specialists and laymen more effective. In particular, many recent studies related to the questions of scientific communication were aimed at revealing those features which are specific to popular science texts and which are not typical of purely scientific and fiction texts (Adams-Smith, 1984; Bowler, 2009; Ciapuscio, 1993; Corbett, 2006; Crystal, 1988; Dahlstrom & Ritland, 2012; Dubois, 1986; Fahnestock, 1986; Funkhouser & Macoby, 1970; Gregory & Miller, 1998; Harvey, 1995; Hempel & Degand, 2008; Hyland, 2009; Kahn, 1983; Loffler-Laurian, 1984; Mortureux, 1985; Myers, 2003; Paul, 2004; Rowan, 1989; Shinn & Whitley, 1985; Varantola, 1987; Zhang, 2015). For example, Rowan (1989) found that, because of the difference in the goals of professional science and popular science writers, jargon and passive constructions prevail in professional science texts. However, as the results of Rowan's research have shown, even in the text of research articles the above-mentioned linguistic means are more likely to be found in those sections which would warrant their actual use.

At the same time, Hempel and Degand (2008) explored the use, frequency, and distribution of structuring devices (particularly sequencers) in three different text genres: academic writing, journalese (including popular science and newspaper articles) and fiction. The obtained data suggest that, compared to fiction, academic writing is much more structured and homogeneous in terms of the amount and actual use of sequencing devices. Journalese is situated between the other two genres, which may be caused by the diversity of articles, subjects, authors, and attitudes.

At present, much attention is also paid to the questions of popularizing scientific information in mass media. The 1980s and 1990s are often associated with a significant upgrade of mass media. Many new types of publications written in different languages, intended for different categories of readers, and covering the questions related to various fields of studies had already appeared by that time. Conducting quantitative and qualitative analysis of different aspects of popular science texts enables researchers to reveal and describe some important structural, pragmatic, and linguistic characteristics of popularized texts published in different kinds of mass media (e.g., Gallardo, 2005; Giannoni, 2008; Jones, Connell, & Meadows, 1978; Nwogu, 1991; Taylor, 1975). One of such studies conducted by Nwogu (1991) led the researcher to conclude that from four to nine different moves can be realized in a typical text of the journalistic reported version (JRV) of research articles. The lack of uniformity in the quantity and hierarchical organization of the moves observed in this kind of popularized texts shows that numerous variations exist in the application of schema-theoretic principles to the analysis of naturally occurring language data.

Another related study was conducted by Gallardo (2005). The main purpose of his research was to identify the type of utterances which support recommendations in 58 texts published in two popular Argentinean newspapers in 1998-1999. The researcher distinguished among functions aimed at achieving comprehension of the main purpose, facilitating the necessary readers' action(s), and achieving readers' acceptance. The latter showed the highest frequency. Supporting functions were also analyzed in terms of the speakers' acceptance of responsibility. The researcher considered whether they are formulated as a direct or indirect quotation of the information source, or whether the reporter didn't formulate any reference to it.

The data obtained showed that most of supporting functions justifying recommendations are formulated as a direct quotation of the specialist's words.

Finally, in his study of popularizing features in English journal editorials, Giannoni comes to the conclusion that the major popularizing features are expressed via personalization, contingency, and humor. At the language level, they are represented by questions, marked lexis, metaphors, and appeals to the reader. However, their quantity varies depending on the subject area of the journals where popularized texts are published.

The growing importance of popular science publications led to the necessity of conducting research on various language and pragmatic features that make communication between specialists and laymen more effective. Among popular science publications, the most common type is the Popular Science (science popularization, or popular scientific) Article (PSA), both in printed and electronic formats (e. g. Adamsone-Fiskovica, 2015; Chernyavskaya, 2004; Dahlstrom & Ritland, 2014; Lazarevich, 1978; Molek-Kozakowska, 2016; Parkinson & Adendorff, 2004). Several studies have focused on specific individual features of this kind of popular science writing, including the use of hedging (Hyland, 2010; Varttala, 1999) and reporting verbs (De Oliveira & Pagano, 2006) in the text of the PSAs published in printed magazines. For instance, in his study, Hyland (2010) showed that, unlike research articles which are usually much more "impersonal" and "transparent" in terms of their argument structure and general organization, in PSAs, proximity reveals itself through the use of different structural and linguistic means which help their authors make research more accessible for non-specialists and enable them to recover the voice of the scientist.

The analysis of the communicative functions of hedging in popular science and specialist research articles on medicine undertaken by Varttala (1999) enabled the researcher to conclude

that different kinds of lexical hedges can be used as a textual tool for stating imprecision/precision and for ensuring interpersonal positive politeness in popularized communication between specialist writers and non-specialist target audience.

The data obtained from the quantitative and qualitative analysis of online research and popular science articles written in Brazilian Portuguese, which was conducted by De Oliveira and Pagano (2006), show disciplinary differences in the frequency of employing reporting verbs. Besides, the results from that study clearly indicate that reporting verbs play a much more significant role in PSAs compared to research articles. Thus, the words quoted by the authors of science popularization articles are placed in a more discursive position superior to the words expressing their own attitudes and opinions.

Several recent studies also compare some individual language and pragmatic features typical of research and popular science articles (Calsamiglia & Ferrero, 2001; Dahlstrom, 2014; De Oliveira & Pagano, 2006; Hyland, 2010; Molek-Kozakowska, 2017; Moshtaghi, 2010; Myers, 2003; Orlandi, 2001; Parkinson & Adendorff, 2004; Roberts, 2016; Szu, Osborne, & Patterson, 2016; Zamboni, 2001; Zhang, 2015). Most of these studies consist of contrastive analysis in which PSAs are compared with their source texts, – that is, the research articles published in specialized journals. For example, in their study, Parkinson and Adendorff (2004) compare the sources of information, degree of objectivity, reader-writer interrelations and interpersonal differences between PSAs and academic texts, including research articles and textbooks. Based on the general qualitative analysis of these three types of publication, the researchers conclude that popular science texts differ significantly from academic texts at the level of register, which influences the choice and use of different linguistic means in both types of texts.

All above-mentioned studies have contributed much to enhancing our understanding of some individual structural, linguistic, and pragmatic features peculiar to popular science texts in

general and to some of their genres and varieties, including some kinds of popularized texts published in printed and electronic mass media. However, an issue that remains to be up-to-date about most of these studies is connected with the fact that they are often aimed at comparing some individual peculiarities of some genres of popular science texts (or popular science texts in general) with those characteristic of research articles, fiction, etc. At the same time, very few of them provide a systematic description of different linguistic and pragmatic features typical of concrete genres of popular science texts and connected with their communicative and pragmatic purposes. Therefore, more in-depth studies need to be conducted for revealing those linguistic, structural, and pragmatic features which distinguish this or that genre of popular science texts from other kinds of popular science writing, including the texts of PSAs.

As shown earlier, while PSAs are written, first of all, for the purposes of conveying some scientific content, they may also contain their authors' personal evaluations, opinions and interpretations of the things discussed in those articles (Alexeeva, 2000; Lazarevich, 1978). Thus, it means that PSAs may include both factual and emotional or evaluative information. So it is logical to assume that the authors of PSAs need to use certain linguistic and rhetorical devices to be able to balance their dual goals of reporting objective and accurate factual and scientific information in an accessible and engaging way, on the one hand, and conveying the researchers' and the authors' personal evaluations and opinions, on the other hand. In this connection, it is possible to conclude that investigating the use of certain linguistic/stylistic and rhetorical devices which are frequently employed in PSAs for conveying the necessary scientific and/or evaluative information in an illustrative and vivid form should allow us to determine certain rhetorical and linguistic characteristics differentiating PSAs from some other kinds of popular science writing. This should let us reveal some specific ways of conveying scientific content in popular science

magazines which are considered the main venue for delivering scientific information to non-specialist audiences as well as for increasing their interest in science and for improving their understanding of it (e. g. Chernyavskaya, 2004; Lazarevich, 1978; Parkinson & Adendorff, 2004).

In this dissertation project, I am focusing on investigating the use of theory-constitutive metaphors (that is, the metaphors employed by scientists for expressing theoretical claims for which no adequate literal paraphrase exists yet (Boyd, 1993)), similes and scientists' narratives about their travel/research experience in the text of PSAs. In particular, it addresses the following research question: in what way do different contextual factors (namely, the subject of articles and the assumed degree of the readers' familiarity with it as well as some specific characteristics of a particular magazine and its intended audience) determine the use of these linguistic and rhetorical devices in the text of PSAs? According to research literature (e. g. Avraamidou & Osborne, 2009; Bucchi, 1998; Holton, 1986; Keller, 1995; Leary, 1990; Semino, 2008), the above-mentioned linguistic and rhetorical devices tend to be used in PSAs for conveying the necessary factual information in a compact form (that is, arranged within a relatively small space and presented in a more concise and less verbose form), including presenting and explaining certain scientific phenomena, scientific issues or advances and new understandings of those phenomena which were studied and discussed in certain areas of science earlier as well. Introducing them into the text of PSAs allows the authors of PSAs to form in the reader's mind some new associations and ideas related to the topic of their articles. At the same time, as demonstrated in some previous research (e. g. Badenschier & Wormer, 2012; Norris, Guilbert, Smith, Hakimelahi, & Phillips, 2005; Valiverronen & Hellsten, 2002; Warren & Power, 2015), in some cases, their use enables the authors of PSAs to describe and promote their own views,

attitudes and beliefs related to the subject of discourse. Thus, it is possible to assume that examining the ways of using theory-constitutive metaphors, similes and scientists' narratives about their travel/research experience in the text of PSAs should allow us to explore different factors and characteristics of PSAs as a specific medium which is mostly aimed at reporting the necessary factual and evaluative information to the lay audience in a dynamic and engaging way.

Furthermore, the analysis of PSAs published in different sources and/or dedicated to different subjects should help us arrive at a better understanding of various contextual factors which may influence their linguistic and pragmatic features. In particular, examining the use of the above-mentioned rhetorical and linguistic means in the text of PSAs published in different magazines and/or dedicated to different subjects should enable us to find out whether the subject of an article, the communicative and pragmatic purposes of the author of a concrete article and the specific characteristics and requirements of a concrete source may have some influence on the ways of representing factual and evaluative information in the text of a concrete PSA. Eventually, this should improve our overall understanding of the language mapping of the world reflected in the text of this particular kind of popular science writing.

This dissertation includes three interrelated studies examining the use of theory-constitutive metaphors, similes, and scientists' narratives about their travel/research experience in the text of PSAs, respectively. These studies are presented in Chapters 2-4. In particular, Chapter 2 ("On the Use of Theory-Constitutive Metaphors Introduced into the Text of Popular Science Articles") is aimed at analyzing the ways of introducing theory-constitutive metaphors into the text of popular science articles dedicated to two different subjects, – namely, astronomy and biology. It also includes the data about the normalized frequency of using this kind of metaphor in these two varieties of PSAs.

The fact that theory-constitutive metaphors are commonly employed by specialists working in the same area of science and that they may not be familiar to those people who are not specialists in that certain area of science determines their use in the text of PSAs. In particular, the results of this study show that the number and the ways of introducing this kind of metaphor into the text of astronomy and biology PSAs are characterized by some common and varying features discussed in the second chapter of the dissertation. For example, in many cases, the readers of *National Geographic* and *Discover* can understand the meaning of theory-constitutive metaphors based either on the explicit definitions accompanying them in the text of the article or on the context and their own background knowledge. However, the number of the metaphors introduced with the help of definitions is higher in the astronomy articles, compared to the articles about biology. At the same time, the theory-constitutive metaphors whose meaning needs to be inferred from their context prevail in the biology articles. This tendency can be connected with the assumed degree of the readers' familiarity with the subject of these articles and with the current level of understanding of the scientific phenomena studied by astronomers and biologists.

Another linguistic phenomenon which may realize mappings across different conceptual domains and which is often used in the text of PSAs is simile. Chapter 3 of this dissertation project ("On the Use of Simile in the Text of Popular Science Articles") presents the corpus analysis of the similes introduced into the PSAs published in two magazines (namely, *National Geographic* and *Discover*) which are intended for different categories of non-specialist target audiences. It follows from the results of this study that the lexical structure of the similes used in the PSAs from these two magazines is characterized by certain similar features. For example, in many cases, the use of stylistically neutral nouns/adjectives, synonyms of scientific terms, and

colloquial lexical units in the structure of those similes allows the authors of PSAs to convey the necessary factual information in an accessible way. At the same time, the presence of evaluative adjectives, lexical intensifiers or mitigating devices in their structure enables the authors of PSAs to convey the elements of their and/or the researchers' personal judgements and evaluations.

Nevertheless, as shown in Chapter 3, in some cases, the differences in the target audiences of *National Geographic* and *Discover* may influence the lexical structure of similes and their number in the articles from these two magazines. For example, the articles from *National Geographic* usually include more evaluative information, compared to the articles from *Discover* containing mostly the scientific information related to their subject. This is probably the main reason why the similes performing mostly the evaluative function tend to prevail in the articles from *National Geographic*, and the similes conveying the necessary factual information – in the articles from *Discover*.

In some cases, the metaphorical expressions and similes introduced into the text of PSAs can be used in different types of narrative, including the narratives about the research and/or travel experience of the scientist(s) involved in the project discussed in the article. As demonstrated in Chapter 4 ("On the Use of Narratives about Scientists' Travel and/or Research Experience in the Text of Popular Science Articles"), along with some other linguistic and stylistic means (e. g. proper names, well-known terms, evaluative lexical units, idioms, etc.), the similes and metaphors deployed in such narratives can be used for conveying the necessary factual or evaluative information connected with different stages of the research presented in the articles from *National Geographic* and *Discover*.

At the same time, the results of the study presented in Chapter 4 show that the use of this type of narrative in the text of PSAs from these magazines is characterized by some varying and

invariant features discussed in the chapter. This refers to the communicative and pragmatic purposes of using this kind of narrative in the PSAs from two different magazines as well as to the linguistic means helping their authors achieve those purposes. For instance, in both varieties of articles, scientists' narratives about their travel and/or research experience are often deployed for providing the necessary information about the context and the most important aspects of the research described in the article. Using direct quotations and such linguistic devices as evaluative lexical units, metaphorical and set expressions in these narratives allows writers to add authenticity to their narration as well as to share with the readers their own and/or researchers' evaluations of the subject of the article. At the same time, in the articles from *Discover*, this type of narrative is typically used, for instance, for providing the necessary factual and evaluative information about the data collection or experimentation process, and in the articles from *National Geographic* – for expressing the author's attitude to the observations and interpretations suggested by scientists, conveying their own hypotheses or assumptions, and/or for informing the readers about the major results of one's research. Variations discussed in Chapters 3 and 4 point to the fact that the target audience of the articles and specific purposes of the magazine where they are published need to be regarded as the contextual factors affecting the use of this kind of narrative in the text of PSAs.

The findings obtained in the studies presented in Chapters 2-4 of this dissertation project may have some important theoretical, methodological, and practical implications. In particular, the results of this project contribute to the research into typological rhetorical and linguistic parameters which would help us distinguish between PSAs and other kinds of popular science texts. These parameters include the typical forms of introducing theory-constitutive metaphors into the text of PSAs, peculiarities of the lexical structure of similes employed by the authors of

PSAs as well as the communicative and pragmatic purposes performed by scientists' narratives about their travel and/or research experience in PSAs discussed in Chapters 2-4; a more detailed discussion of these typological parameters of PSAs can be found in the final chapter of the dissertation (Chapter 5) together with the discussion of the major results of this project and their implications, limitations and some possible directions of the further research connected with the topic of the dissertation.

Certain methodological implications may follow from the results of this dissertation project as well. Based on the findings obtained in this project, it is possible to conclude that investigating the language of PSAs in close connection with their content makes the research of the linguistic/stylistic and rhetorical features of PSAs more diverse and productive. For example, examining certain linguistic and stylistic means within the narratives in which they are used allows researchers to investigate the communicative and pragmatic purposes performed by them in the actual discourse in which they are employed. Analyzing the use of similes in connection with the surrounding context provides researchers an opportunity to understand better the reasons for the presence of certain elements in their lexical structure (e. g. colloquialisms, evaluative adjectives, lexical intensifiers and mitigating devices, etc.), including the necessity to show the logical connections between different objects or phenomena, to share with the readers the author's or the scientist's position towards the subject of the PSAs, and so on. Considering the topic and the main content of PSAs in the process of investigating the use of theory-constitutive metaphors in the text of PSAs enables researchers to understand better the reasons for introducing them there this or that way (e. g. with the help of definitions, real-life stories and examples, personifications, etc.). This correlates with the claims of several applied linguists (e. g.

Ferguson, 2001; Lemke, 2002; Mohan, 1986), according to which language and content are not completely distinct, as language is a medium for mapping content to expression.

The analysis conducted within this dissertation project may also have some important practical implications for scientists and science journalists reporting research to non-specialist audiences. In particular, investigating the above-mentioned linguistic and rhetorical features of PSAs should allow us to arrive at a better understanding of certain strategies and techniques helping the authors of PSAs to convey the necessary scientific content in an accessible and engaging way. Eventually, the use of those linguistic/stylistic and rhetorical devices should enable the readers of PSAs to achieve a better and more precise understanding of the phenomena denoted by them, and hence of the subject of the articles where they are employed. Thus, it is possible to conclude that in many cases, introducing those devices into the text of PSAs should allow their authors to make scientific results intelligible and interesting to a general readership.

Finally, it is worth mentioning here that the results of this dissertation project may also have certain pedagogical implications. For example, it is possible to assume that reading and analyzing the texts of PSAs in ESL/EFL (English as a second/foreign language) lessons can help learners enrich their own range of various linguistic and rhetorical means which they can use in different communicative situations (for example, when trying to convince somebody that their point of view is well-justified and true-to-life, or when presenting the necessary factual information in a logical, coherent and engaging way, and so on). In addition, the texts of PSAs can be used for showing EFL/ESL learners that the same linguistic/stylistic and rhetorical means can perform different functions in different kinds and varieties of the same genre. Introducing PSAs into EFL/ESL and ESP/EAP lessons should enable teachers to emphasize the necessity to consider the author's communicative and pragmatic purposes, his/her rhetorical appeals, place

and purpose of publication, target audience, and other contextual factors when reading and interpreting the content of this kind of popular science text. At the same time, PSAs can be effectively used for developing some activities aimed at teaching students how to separate factual information from the author's personal judgments, opinions, hypotheses, etc. Finally, the results of some related studies (e. g. Parkinson & Adendorff, 2004; Zhang, 2015) suggest that PSAs can make science accessible to students, which means that they can play a useful role in the teaching of scientific writing as well as in the teaching of science. They can also become a good basis for developing students' practical skills of writing an argumentative essay, participating in a scientific dispute or discussion, or presenting scientific information in such a way that it could be clear and accessible to non-specialist audiences as well.

CHAPTER II

ON THE USE OF THEORY-CONSTITUTIVE METAPHORS INTRODUCED INTO THE TEXT OF POPULAR SCIENCE ARTICLES

Introduction

One type of linguistic device which is intensively used in scientific discourse, including PSAs, is metaphor. In this dissertation, the term "metaphor" is used to refer to the phenomenon which takes place when people speak and, potentially, think about something in terms of something else (Semino, 2008). In particular, metaphors can be used to make sense of and frame complex phenomena as well as to provide lexical resources when little or no specific vocabulary exists for particular topics.

Studies of the metaphors used in science communication have largely focused on the existence, application, and function of metaphors in specialist scientific discourse, in some way overlooking the use of scientific metaphors in non-specialist discourses, in particular that of popularization (Knudsen, 2003). At the same time, as well as in other kinds of science discourse, in popular science writing, metaphor is necessary because most productive theorizing involves the use of analogies which can play an important creative role in structuring problems of research and professional practice in different areas of science (Dunn, 1980). As suggested in some studies (e.g. Bostanci, 2010; Camus, 2009; Hamilton, 2003; Knudsen, 2003; Semino, 2008; Semino, Deignan, & Littlemore, 2013; Valiverronen & Hellsten, 2002), similar to journal article

and other kinds of publications intended for other specialists in the same area, in popular science texts, metaphors are frequently used for conveying the necessary factual information. In particular, the authors of popular science texts resort to metaphors when presenting and explaining the necessary scientific phenomena, scientific issues or advances and new understandings of those phenomena which were studied and discussed in certain areas of science earlier as well. In such cases, in accordance with Brown (2003), Jacobi and Schiele (1988), Sternberg (1990), and some other researchers, it is possible to say that metaphor serves the informative (or cognitive) function in different kinds of scientific texts, including the texts of PSAs aimed at reporting science to non-specialist audiences.

The meanings of metaphors are culturally produced and depend on the wider context and domains of their practical use, social practices of communication, available resources and the actual purposes of the users (Chiappe, 1998; Gantt, Melling, & Reber, 2012; Hellsten, 2000; Leydesdorff & Hellsten, 2005; López, 2007; Miller, 1985; Wingens, 1990). It also enables them to describe and promote their own views, attitudes and opinions related to the subject of discourse in a convincing, accessible and vivid way (Bucchi, 1998; Holton, 1986; Keller, 1995; Semino, 2008; Valiverronen & Hellsten, 2002; Warren & Power, 2015). Thus, it is possible to say that, in some cases, metaphors can perform the evaluative function in science popularizations (including PSAs) too.

Similar to other kinds of discourses, the necessary factual and evaluative information can be conveyed in PSAs and other kinds of popular science texts with the help of conventional metaphorical expressions in language, which people often use and understand without being conscious of their metaphoricity. As shown by Lakoff and Johnson (1980), such expressions reflect conventional patterns of thought, known as “conceptual metaphors.” Conceptual

metaphors are defined as the cognitive phenomena whereby one conceptual domain (the target domain) is understood in terms of another (Semino, 2008). For instance, in the conceptual metaphor "life is a journey," "life" is the target domain which is thought and talked about in terms of another, source domain – "journey." Conceptual metaphors involve mappings, or sets of correspondences, from source to target domain. For example, in the above-mentioned conceptual metaphor "life is a journey," the person living his/her life corresponds to a traveller.

According to Lakoff and Johnson (1980), a conceptual metaphor is conventional to the extent that it is automatic, effortless, and generally established as a mode of thought among members of a linguistic community. In this case, "conventional" also applies to the connection between the conceptual and linguistic levels. When people speak of the degree to which a conceptual metaphor is conventionalized in the language, they mean the extent to which it underlies a range of everyday linguistic expressions. Conventional metaphor has infused into every aspect of the society. Therefore, people can easily understand and use the expressions actively used in everyday life without realizing that a metaphorical conceptualization is being processed (Lakoff & Turner, 1989).

As well as in other kinds of scientific discourse, along with the conventional metaphors which should be familiar to any member of the same linguistic community, the necessary scientific content is often delivered in popular science writing via so called "theory-constitutive" metaphors. According to Boyd (1993), theory-constitutive metaphors provide vocabulary for the phenomena for which scientists do not have (or do not have yet) any alternative terms and formulations (e. g. "transcription" or "translation process" in relation to DNA). It is probably what Montgomery (2003) refers to as "metaphoric terminology" (e. g. "white dwarf star," "killer T-cell," "quantum charm," "reporter genes," and so on) which is frequently used in scientific

literature. In his opinion, this shows how strong and accepted the metaphorical impulse remains in science. This contention resembles Bucchi's (1998) observation, according to which metaphors allow the creative imagination of scientists "to float freely between the scientific world and life-world experience" (p. 24).

It was also shown by Boyd (1993) that theory-constitutive metaphors are typically fully explicated within a particular discipline; as well as conceptual metaphors, they rely on the mapping of structural relations from source to target domain. For example, in the theory-constitutive metaphor "book of life" which is widely used in genetics when referring to the genetic code, the target domain is "gene" or "genome," and the source domain is "book." The use of a familiar everyday object (in this case, "book") as the source domain makes the unfamiliar (in this case, "gene" or "genome") seem familiar and comprehensible. This probably explains why theory-constitutive metaphors are typically used in different kinds of science discourse.

Theory-constitutive metaphors are typically introduced in order to be adopted and developed by the relevant scientific community; in many cases, successful scientific metaphors become an essential part of the technical discourse of that community (Cameron, 2003; Semino, 2008). This process results in the progressive specification of the target domain-specific senses of metaphorical technical terms, which then become conventionalized within particular scientific communities (Domínguez, 2015; Knudsen, 2003; Larson, Nerlich, & Wallis, 2005; Maasen & Weingart, 1995; Semino, 2008).

While previous research on theory-constitutive metaphors mostly focused on theory-constitutive metaphor as a conceptual phenomenon (Boyd, 1993; Knudsen, 2003; Larson, Nerlich, & Wallis, 2005; Maasen & Weingart, 1995), as demonstrated by Semino (2008), when

people speak of the degree to which a certain theory-constitutive metaphor is conventionalized in the language, they mean the extent to which it underlies a range of actual linguistic expressions in scientific communication. This shows the importance of investigating the linguistic and textual realization of theory-constitutive metaphors in different scientific genres, including PSAs and other kinds of science popularizations, within a range of disciplines. At the same time, when analyzing the linguistic representation of theory-constitutive metaphors in the texts of science popularizations, it is necessary to take into account that, while these metaphors are commonly used by specialists working in the same area of science, they may not be familiar to those people who are not specialists in that certain area of science (Bostanci, 2010; Domínguez, 2015; Valiverronen & Hellsten, 2002). This may influence their linguistic representation in the texts aimed at reporting science to the general public (e. g. the presence or absence of the author's explanations and definitions of those metaphors, including in the author's narration additional examples illustrating their meaning, introducing their synonyms which should be already familiar to the lay reader, etc.). Thus, it is possible to conclude that examination of the linguistic realizations of theory-constitutive metaphorical expressions in their actual discourse content should allow us to reveal similarities and differences in their use in the text of PSAs dedicated to different subjects and topics. Therefore, more in-depth studies need to be conducted for improving our understanding of the ways in which the textual manifestations of theory-constitutive metaphors may influence the processes of inferring and constructing the necessary meanings delivered in this particular kind of scientific discourse.

The aim of the study presented in this chapter is to investigate different tendencies observed in the ways of introducing theory-constitutive metaphorical expressions into the texts of PSAs which typically serve as a specific medium aimed at conveying the necessary scientific

content to the lay audience. Kimmel (2012) notes that the metaphor analyst may try to capture all metaphors in their corpus, but that, more usually, "a restriction to one or a small set of domains makes sense because the researcher wants to maintain a thematic focus" (p. 5). He and several other researchers (e. g. Bostanci, 2010; Brown, 2003; Domínguez, 2015; Semino, 2008) explain that limiting the corpus of one's study of metaphor to the texts dedicated to one or a small set of subjects should allow researchers to reveal some specific factors which may influence the use of metaphors in the same kind of texts dedicated to different subjects (including the grammatical or semantic structures of those metaphors as well as the ways of using them in oral and written communication, the presence of stylistically neutral and stylistically colored lexical units in metaphorical expressions, etc.). The study described in this chapter addresses the following research questions which are based on this approach to conducting metaphor research:

1. In what way does the subject of a PSA influence the use of theory-constitutive metaphors in the text of PSAs dedicated to different subjects (namely, astronomy and biology)?

2. What forms of introducing theory-constitutive metaphors are used for conveying the necessary information in the text of PSAs dedicated to different subjects (namely, astronomy and biology)?

Thus, the main purpose of the study discussed in this chapter is to analyze the use and different ways of introducing theory-constitutive metaphors into the text of PSAs dedicated to two different subjects (namely, biology and astronomy) and intended for the readers who may not be specialists in the subject of those articles. The results of this analysis will enable us to arrive at a better understanding of some important peculiarities associated with applying this kind of metaphorical expressions in the text of PSAs, including the use of definitions, real-life stories and/or examples, the elements of personification, comparison, and many other devices for

introducing theory-constitutive metaphors into the text of the PSAs about astronomy and biology.

Research Design

The method of qualitative descriptive analysis prevails throughout the studies presented in this and in the next two chapters of the dissertation. The study discussed in this chapter was aimed at analyzing the use of theory-constitutive metaphorical expressions in the text of PSAs. I define PSAs as texts which are initially published in the magazines or on Web-sites intended for non-specialist target audiences and which are written, first of all, for the purposes of conveying some scientific content in the form accessible to those people who may not be specialists in that certain area of science; at the same time, PSAs typically contain their authors' personal evaluations, opinions and interpretations of the things discussed in those articles (Alexeeva, 2000; Lazarevich, 1978). Thus, it is logical to conclude that PSAs include both the elements of factual and emotional or evaluative information.

The approach to the identification of metaphorical expressions in the corpus of the study employed in this analysis was based on the metaphor identification procedure (MIP) described by Pragglejaz Group (2007), as it starts from the actual discourse and inductively builds the case for determining whether a particular word was used metaphorically in context. This procedure includes reading the entire text for establishing a general understanding of the meaning, identifying the lexical units (including both individual words and multi-word expressions), establishing their meaning in their actual context, and determining whether they have a more basic contemporary meaning in other contexts than the one in the given context (Pragglejaz Group, 2007). According to Semino (2008), basic meanings are usually mostly more concrete,

related to biological senses and bodily action, more precise (as opposed to vague) and historically older. At the final stages of the MIP, it is necessary to determine whether the contextual meaning contrasts with the basic meaning but can be effectively understood in comparison with it; if yes, then the lexical unit can be marked as metaphorical (Pragglejaz Group, 2007). For example, in one of the articles analyzed in this study, Schupak (2015) uses the expression "a white dwarf": "The first process occurs in binary star systems where at least one star is *a white dwarf*, a dense, aging star that can no longer support nuclear fusion"[1] (p. 38). According to the definition of the word "dwarf" provided in the online Webster Dictionary (http://www.merriam-webster.com/dictionary/), dwarf is "a person of unusually small stature," "an insignificant person," or "an animal or plant much below normal size." However, in the context of the article, the word "dwarf" refers to a star of ordinary or low luminosity and relatively small mass and size. Thus, in this case, the contextual meaning of the word "dwarf" contrasts with its basic meaning and can be easily understood by comparison with it: we can understand that, analogically to a person of unusually small stature or an animal/plant much below normal size, the expression "a white dwarf" refers to the stars having a smaller size, compared to other kinds of stars. Thus, it is possible to conclude that in the context of that astronomy article, the expression "a white dwarf" can be considered metaphorical.

In order to be able to research the use of metaphors in the text of PSAs, the method of corpus analysis was applied in this study. In particular, the research presented in this study included identification and analysis of the purposes and ways of introducing theory-constitutive metaphors into the text of the articles investigated in this study. The Corpus of Contemporary

[1] In this and all other examples from the text of PSAs cited in this chapter, metaphorical expressions have been italicized by me.

American English (COCA) (Davies, 2008-) was used for attributing the metaphorical expressions identified in the corpus of study to the theory-constitutive ones and for differentiating them from other kinds of metaphors, including conventional and novel metaphorical expressions. All those metaphorical expressions which, according to the COCA, are typically used only in a specific domain, were regarded as theory-constitutive metaphors. This way of coding theory-constitutive metaphors in the corpus of this study corresponds with the approach suggested by Hu and Chen (2015). According to this approach, in those cases when a metaphor or metaphorical expression is employed in at least 90% of the examples of its use found with the help of the COCA or any other corpus tool, it needs to be regarded as a theory-constitutive metaphor. For example, in several articles analyzed in this paper, their authors use the metaphorical expression "Big Crunch." The COCA database contains 51 examples of this metaphorical expression. 48 of those examples (that is, approximately 96%) are taken from the scientific texts related to the questions of astronomy. Therefore, we can conclude that "Big Crunch" should be considered a theory-constitutive metaphorical expression.

The evidence presented in this paper was collected from 20 popular science articles dedicated to the questions of astronomy and biology (see the References). Choosing only 20 articles for the corpus of this study was connected with the fact that, as shown by Kimmel (2012), selecting the texts of the same kind consisting of 24,000-26,000 words in total allows the analyst to conduct a more in-depth and focused qualitative study of certain trends and characteristics associated with the use of a particular kind of metaphors in that particular type of text. The articles selected for this study consist of 26,312 words in total (13,124 words in the astronomy articles, and 13,188 words in the biology articles). The astronomy articles investigated in this study included the articles presenting the research into certain processes and

phenomena taking place on particular planets and in the cosmos in general as well as the articles about dark energy, dark matter, black holes, and different theories of the origin of the universe and some possible scenarios of its future development (e. g. Big Bang, Big Crunch, Big Rip, etc.). The biology articles included in the corpus of this study contain information about the research into zoology, botany, ecology, and genetics. It follows from the data provided by Ngumbi (2018) and Pain (2015) in their guidelines for the writers of popular science texts that these topics are discussed in most of the articles published in modern popular science magazines. Therefore, it is possible to conclude that choosing the PSAs dedicated to the topics enlisted above will make the results obtained in this study relevant and important for understanding certain trends connected with the use of theory-constitutive metaphors in modern PSAs. Besides, according to Myers (2003), the texts dedicated to these fields of study tend to be focused on one topic at a time, unlike many other astronomy and biology texts whose content tends to be more interdisciplinary and hence related to different fields of study at the same time (as it takes place, for example, in the texts about immunology which typically include the data from physiology and from some other areas of biology, medicine, and pharmaceuticals at the same time). Therefore, it is possible to conclude that choosing the PSAs dedicated to the topics enlisted above will allow us to make sure that all articles investigated in this part of the dissertation project are dedicated either to astronomy or to biology.

The choice of these two subjects – astronomy and biology – for the purposes of this study is connected with the fact that people's degree of familiarity with these two subjects can be quite different. For example, as demonstrated by Ehrenstein (2010), different phenomena investigated by biologists can be more familiar to the general public compared to those studied by astronomers. According to the results of her study, it usually can be explained by the fact that in

many countries, secondary school curricula typically give more priority to teaching biology than to teaching astronomy. Besides, people tend to be surrounded by various species of plants and animals which people may see in nature or in the zoo, have at home or observe in the surrounding environment. According to Ehrenstein (2010), this also increases the degree of their familiarity with biology. At the same time, she notes that most of the processes and phenomena associated with astronomy can be observed by those people who are not specialists in astronomy only occasionally and only in some special settings and/or with the help of some special equipment. These differences in the assumed readers' familiarity with the phenomena investigated by biologists and astronomers determine the different ways in which theory-constitutive metaphors can be used in the astronomy and biology articles.

All articles investigated in this study were originally included in the US single issue printed magazine called "Popular Science. 100 Mysteries of Science Explained"; it was published in 2015. This magazine is intended for the broad category of people interested in the questions of astronomy and physics in general as well as biology and a wide range of some other related areas of natural sciences (e. g. geography, geology, meteorology, etc.). The authors of the articles investigated in this study are science journalists or, in some cases, experts in the fields related to the subject of the articles. Scientific information provided in their articles (as well as in all other PSAs investigated in this dissertation project) is based on the content of the scholarly articles, monographs, and other scientific publications where the research they report on in their articles was originally published. At the same time, all these articles are intended for non-specialist target audiences, which means that the readers of these articles can be people of different age, having different educational background as well as different level of interest and current knowledge related to the subject of the particular articles. Using this research material for

the purposes of the study should help us understand whether and to what extent the subject of a PSA may determine the choice and actual ways of using theory-constitutive metaphors in the process of conveying the necessary scientific information and ideas to non-specialist audiences.

It has been shown in research literature that different kinds of metaphor can be introduced into oral and written communication science in various ways, including the use of explicit definitions, non-metaphorical synonyms and paraphrases, real-life examples and stories illustrating the meaning of a particular metaphor, etc. (Gastel, 1983). For the purposes of this part of the dissertation project, the following classification of the forms of introducing theory-constitutive metaphors into PSAs was developed and applied:

- providing an explicit definition of the target metaphor;
- explaining the etymology or origin of theory-constitutive metaphors;
- based only on the context and the reader's background knowledge (that is, without providing any explicit clues in the text of the article);
- using the word "called" when introducing a new theory-constitutive metaphor;
- mentioning one or two important features of a certain scientific phenomenon;
- sharing with the readers the author's evaluations and other additional details connected with a certain phenomenon (with the help of evaluative adjectives and adverbs, lexical intensifiers and other lexical units conveying the author's position to the subject of the article);
- comparing a scientific phenomenon with another process or phenomenon familiar to the lay readers;
- providing the explanations of a scientific phenomenon suggested by different scientists;

- exemplifying/specifying the meaning of a new theory-constitutive metaphor;
- using the elements of personification; and
- providing a real-life story related to a certain scientific phenomenon.

This classification is based on the results of the analysis of all those theory-constitutive metaphors which were revealed in the corpus of this study. In accordance with the criteria suggested by Kimmel (2012), those forms of introducing theory-constitutive metaphors which were identified in at least 20% of all instances of using this kind of metaphor in the corpus of the study were included in this classification for the purposes of their further analysis discussed in this chapter.

It is also necessary to mention here that, in addition to the qualitative analysis of theory-constitutive metaphors, the normalized frequency of using theory-constitutive metaphors (including repetitions of the same metaphorical expressions) per 1000 words was calculated and compared in the astronomy and biology articles for revealing some additional trends connected with the use of this kind of metaphor in PSAs. To calculate the density of theory-constitutive metaphors in each variety of PSAs, the following formula presented in McEnery & Hardie (2014, p. 49) and on the Web-site of the Department of Linguistics and Modern English Language, University of Lancaster (https://www.lancaster.ac.uk/fss/courses/ling/corpus/blue/l05_3.htm) was applied throughout this study:

nf = (number of examples of the word in the whole text / size of the text) *

* (base of normalization)

At the same time, since metaphors (including theory-constitutive metaphors) may include more than one word, for the purposes of the study discussed in this chapter, this original formula

was modified in accordance with the suggestions of Wahl and Gries (2018) provided for the analysts doing quantitative research into the use of multi-word expressions in discourse:

nf = (number of examples of the lexical unit in the whole text / size of the text) *

* (base of normalization)

In accordance with this formula, the total number of the lexical units within theory-constitutive metaphors revealed in the astronomy and biology articles investigated in this study was divided by the number of words in the whole corpus of the articles belonging to the same variety of PSAs; then the resultant number was multiplied by 1000. Calculating and comparing the normalized frequency of using the theory-constitutive metaphorical expressions introduced into the text of the astronomy and biology articles enabled me to determine in which of these two varieties of PSAs this kind of metaphor is employed more often (the data about the frequency of using theory-constitutive metaphors in the text of PSAs, which are presented in the "Data Analysis and Findings" section, were rounded off to two decimal digits).

Data Analysis and Findings

Use of Theory-Constitutive Metaphors in the Astronomy Articles

Let us consider first the ways of using theory-constitutive metaphors in the text of PSAs dedicated to the questions of astronomy. All astronomy articles which were investigated in this study are aimed, first of all, to inform the reader, or to improve the reader's understanding of different phenomena which take (or may take) place in space. In the corpus of the study, these phenomena are described via various theory-constitutive metaphors (see Appendix A) which have been actively used in scientific publications related to the questions of astronomy. The examples of the use of these expressions presented in the COCA database are all taken from the

research articles and other expert texts related to the questions of astronomy. Since these metaphorical expressions are common in the language of scientists studying the phenomena occurring in space, it is logical to conclude that they can be attributed to theory-constitutive metaphors. Perhaps that is why some of these metaphors (namely, *the Big Bang*, *the Big Crunch*, *black hole, dark energy*, and *dark matter*) can be found in the text of more than one article analyzed within this study.

The texts of the astronomy articles investigated in this study contain approximately eighty theory-constitutive metaphorical expressions per 1000 words. Such frequent use of theory-constitutive metaphorical expressions in this variety of PSAs can be explained by the fact that, since many processes and phenomena taking place in the cosmos have not been studied or explained in detail yet, the authors of the astronomy PSAs have to resort to theory-constitutive metaphors more often to be able to refer to and discuss the phenomena related to the subject of those PSAs.

Theory-constitutive metaphors tend to be used in the texts of the astronomy PSAs in those cases when their authors refer to and present some features, phenomena or objects occurring in space or in the universe in general. These metaphors are employed for conveying the necessary factual information related to the subject of these articles. In addition, they do not contain any elements of evaluation or emotion but denote certain phenomena which are studied and described by astronomers. Therefore, it is possible to say that in the context of these articles, they perform the informative (cognitive) function. For example, in his article, Binns (2015) describes various changes in the shape of the universe which might be caused by such forces as gravity and dark energy. He also connects these possible changes in the shape of the universe with Einstein's theory of general relativity, which then enables him to predict different scenarios

of the future development of the universe: "General relativity requires that the universe remain the same throughout (homogeneity) and appear the same in all directions (isotropy). Therefore, the shape of the universe is the result of *push and pull of gravity* and *dark energ*y. This may sound familiar. The same characteristics determine the universe's three possible fates: *the Big Crunch*, *the Big Rip*, and *the Big Chill*" (p. 28). As can be seen from this example, the author uses several theory-constitutive metaphors at the same time when referring to and discussing the major factors determining the actual shape of the universe and when introducing three possible variants of its future changes and modifications. First of all, in the fragment cited above, he resorts to the expression "push and pull of gravity and dark energy" which, according to the COCA, is used by scientists when referring to the process of strengthening and weakening the influence of these physical forces on different features and characteristics of the universe, including its shape and size. Besides, the term "dark energy" itself can be regarded as an example of a theory-constitutive metaphor, as it is used by scientists to refer to a mysterious property of space which is considered the most dominant force affecting the expansion of the universe.

In the example discussed above, the reader needs to infer the meaning of the theory-constitutive metaphorical expressions "push and pull of gravity" and "dark energy" based on his/her world knowledge and the context, as the author of that article does not provide the exact definition or any other additional explicit clues which would help the readers understand the meaning of these metaphors. However, the results of this analysis suggest that the phenomena denoted by theory-constitutive metaphors can be introduced into the text of the astronomy PSAs in different ways. Table 1 outlines different forms of introducing theory-constitutive metaphors revealed into the astronomy articles analyzed in this study.

Table 1.

Forms of Introducing Theory-Constitutive Metaphors into the Astronomy PSAs

Forms revealed in the astronomy articles	The number of occurrences in the corpus of the study	Examples
Providing an explicit definition of the target metaphor	25	"In the strictest sense, *super-Earths*[2] are just the planets with more mass than Earth, but less than a larger planet like Uranus or Neptune[3]." (Binns, 2015)
Mentioning one or two important features of a certain scientific phenomenon	22	"The *white dwarf* can siphon off (or collide with) the mass of its companion star, reigniting nuclear fusion." (Schupak, 2015)
Using the word "called" when introducing a new theory-constitutive metaphor	16	"The universe rapidly emerged from a singularity in an event that is called the '*Big Bang'*." (Rothenberg, 2015)

[2] In this and all other examples from the text of PSAs cited in Tables 1 and 2, metaphorical expressions have been italicized by me.

[3] In this and in all other examples from the text of PSAs cited in Tables 1 and 2, the additional clues helping writers introduce theory-constitutive metaphors into the text of PSAs (e. g. their definitions, author's evaluations, surrounding context, comparisons with other objects and phenomena, etc.) have been underlined by me.

Forms revealed in the astronomy articles	The number of occurrences in the corpus of the study	Examples
Sharing with the readers the author's evaluations and other additional details connected with a certain phenomenon	15	"The *Milky Way* seems to be somewhat extreme in its early development process, as evidenced by its slender figure." (Carey, 2015)
Explaining the etymology or origin of theory-constitutive metaphors	13	"Since this most dominant force in the universe appeared to be an unknown form of energy permeating all of space, Michael S. Turner dubbed the mysterious new something *'dark energy'*." (Norton, 2015)
Comparing a scientific phenomenon with another process or phenomenon familiar to the lay readers	12	"*Dark matter* may take the form of stars and planets we can see; it constitutes about 27 percent of all the matter in the universe." (Taylor, 2015)

Forms revealed in the astronomy articles	The number of occurrences in the corpus of the study	Examples
Providing the explanations of a scientific phenomenon suggested by different scientists	11	"One of the other, smaller galaxies is the *Sagittarius Dwarf*. 'It turns out that it's on the opposite side of the galaxy from us,' Purcell says. Aguirre adds that 'it's hitting the disc from underneath.' Thomas's simulations suggest that these collisions could account for the spiral that we see today." (Burgan, 2015)
Based only on the context and the readers' world knowledge	8	"Under the scenario called the "Big Crunch," the universe's gravity will overcome its expansion and the cosmos will collapse in on itself, resulting in a singularity that may precipitate another *Big Bang*." (Rothenberg, 2015)
Total	122	

As can be inferred from the data presented in the first row of Table 1, to make the necessary scientific content clear and accessible to the general public, in many cases, the authors

of the astronomy articles explain the meaning of the theory-constitutive metaphors which they use in their articles (especially in those cases when they have at their disposal more research data and more definite scientific information connected with the phenomena denoted by those metaphorical expressions). For instance, when speaking about the Big Crunch as one of the scenarios which may determine the shape of the universe in the future, Binns (2015) introduces the related theory-constitutive metaphor only after providing the definition of the phenomenon which it denotes: "Just as a universe with an energy density less than its gravitational pull will eventually collapse in on itself (the *Big Crunch* scenario), the same gravity will overcome dark energy to mold the universe into a sphere" (p. 28). As the lay reader may not be familiar with the phenomenon described in this part of the article and as the purpose of the article is to convey the necessary scientific content in an illustrative and interesting way, the description of the Big Crunch scenario is accompanied by a brief definition of the related term. This should help the intended readers of his article to perceive and adequately understand the scientific information which is presented in it.

In the example cited above, the author mentions the name of a new metaphorical expression ("the Big Crunch scenario") in parentheses, after providing its brief definition ("a universe with an energy density less than its gravitational pull will eventually collapse in on itself"). However, in many other cases, definitions of the theory-constitutive metaphors used in the astronomy PSAs can be given after mentioning the name of the phenomenon denoted by them: "The first process occurs in binary star systems where at least one star is a *white dwarf*, a dense, aging star that can no longer support nuclear fusion" (p. 38). In this fragment of his article, Schupak (2015) mentions the name of the scientific phenomenon denoted by a theory-constitutive metaphor ("a white dwarf") and then provides its brief definition ("a dense, aging

star that can no longer support nuclear fusion") within the same sentence. This way he lets the readers achieve an adequate understanding of its meaning while familiarizing them with the subject of the article in general (that is, with different kinds of binary star systems, including white dwarfs, red giants, main sequence stars, etc.).

It is also worth mentioning here that in many cases, the authors of some other astronomy articles investigated in this study tend to share with the readers more details about the necessary phenomenon, which they usually provide after mentioning the theory-constitutive metaphor denoting that phenomenon. For example, when introducing the subject of her article "What's at the Bottom of a Black Hole?," Neale (2015) familiarizes the readers with the meaning of the expression "black hole" the following way: "*Black holes* are already among the most mysterious objects in the universe… The concept of a tiny star whose gravitational field is so strong that neither light nor matter can escape was so foreign to those who first theorized their existence that even Albert Einstein himself… dismissed the likelihood of their existence" (p. 21). In this case, the author includes in the definition of the expression "black hole" not only the necessary factual information ("a tiny star whose gravitational field is so strong that neither light nor matter can escape") but also shares with the readers certain evaluations expressed with the help of the evaluative adjectives "mysterious" and "foreign." These evaluations reflect scientists' perception of the related phenomenon earlier and nowadays. Including the elements of evaluative information in his narration allows the author to suggest new associations, thoughts, and ideas related to the concept denoted by the metaphor "black hole." The simultaneous use of theory-constitutive metaphors and evaluative lexical units suggests close connection of the factual and emotional-evaluative information conveyed in the text of the astronomy PSAs.

Along with providing a brief explicit definition of a new metaphorical expression and sharing with the readers additional details connected with its meaning, some other ways of introducing theory-constitutive metaphors can be observed in the astronomy articles as well. For example, the use of the word "called" before mentioning a new phenomenon may signal the reader that the author is going to introduce a new theory-constitutive metaphor connected with the subject of the article. At the beginning of his article, Carey (2015) explains the meaning of the metaphorical expression which is used by scientists to denote the phenomenon of the moon illusion: "The moon seems larger when it is near the horizon than when it is high in the sky, a phenomenon called the *moon illusion*" (p. 20). As this example shows, the use of the word "called" enables the author of the article to introduce a new theory-constitutive metaphor itself ("moon illusion") and its short explanation ("the moon seems larger when it is near the horizon than when it is high in the sky") within one sentence. This makes the author's narration both compact and informative at the same time.

Mentioning one or two important features or details about a certain phenomenon denoted by a theory-constitutive metaphorical expression allows the authors of PSAs to convey the necessary scientific information in a dense and compact form as well. When enlisting and describing possible scenarios of the end of the universe, Rothenberg (2015) concentrates on their influence on the expansion of the universe, for example: "That leaves two possible fates for the cosmos: 1) a *Big Freeze*, in which the acceleration eventually halts but the universe keeps expanding, creating a system where heat becomes evenly distributed, allowing no room for usable energy to exist and thus, 'heat death,' or 2) a *Big Rip*, in which the expansion of the universe continues to accelerate forever" (p. 27). To let the readers infer the necessary scientific information, the author gives the names of the scenarios ("Big Freeze" and "Big Rip") and

explains whether these scenarios accelerate or slow down the expansion of the universe. However, the text of the article does not contain the full definition or any additional information regarding the related metaphorical expressions. The tendency to mention only one or two individual characteristics of the phenomenon denoted by a metaphor is probably connected with the fact that using this form of introducing theory-constitutive metaphorical expressions makes scientific narration compact, clear, easy-to-read, and thus accessible to the lay audience.

Comparing the phenomenon denoted by a metaphorical expression with some other phenomenon which should be already familiar to the potential readers of the article is another popular way of introducing new theory-constitutive metaphors into the astronomy PSAs. When familiarizing the readers with the notion of Jupiter's Red Storm, Engber (2015) compares this phenomenon with a terrestrial hurricane: "It is similar to a hurricane on Earth, rotating counterclockwise with a maximum wind speed of 268 miles per hour, almost twice as fast as the worst hurricanes on Earth" (p. 23). Including in this explanation the details about the speed of Jupiter's Red Storm as well as comparing the latter to another phenomenon familiar to the general public ("it is similar to a hurricane on Earth" and "almost twice as fast as the worst hurricanes on Earth") allow the readers to achieve an adequate and precise understanding of the phenomenon denoted by the theory-constitutive metaphorical expression "Red Storm," which is used throughout the text of Engber's article.

In some of the astronomy PSAs investigated in this study, the authors note that certain phenomena denoted by theory-constitutive metaphors have not been studied well yet. In such cases, they tend to provide the explanations of such a phenomenon suggested by different scientists. For example, in the article dedicated to the major characteristics of dark energy, Norton (2015) enlists two different approaches to understanding this phenomenon: "Theorists

have come up with several explanations for *dark energy*. The leading theory claims that *dark energy* is a property of space… Another explanation posits that *dark energy* is a new type of energy field or energy fluid that fills space but affects the expansion of the universe differently than matter and normal energy" (p. 26). At the very end of the article, the author shows explicitly that at present scientists do not have at their disposal enough data about dark energy: "Scientists have labeled this energy 'quintessence,' but we still don't know what it interacts with or why it even exists" (p.26). So it is logical to assume that, since nowadays astronomers do not know much about the phenomenon of dark energy yet and since it is hence impossible to provide the exact definition of this phenomenon, the author of this article prefers to include in his narration the description of several approaches which shed some light on the major characteristics of this phenomenon, including its connection with space and its possible influence on the expansion of the universe. This allows the author to foster in the reader's mind some new ideas, thoughts, and associations connected with this particular phenomenon discussed in his PSA.

Occasionally the texts of PSAs may contain the explanation of the etymology or origin of a new theory-constitutive metaphor when familiarizing the readers with the subject of their articles: "Zwicky, and other astronomers noticing the same phenomenon, concluded 'that something we have yet to detect is providing these galaxies with additional mass, which generates the extra gravity they need to stay intact.' This 'something' is invisible – hence the nickname '*dark matter*' " (p. 33). In this case, Taylor (2015) shows the readers that the use of the metaphor "dark matter" for denoting the phenomenon described in his article is connected with the fact that nowadays very little is known about it and that in the future scientists will have to do much research to be able to understand the nature and the major characteristics of this chemical substance pervading the universe. As well as in the previous case, the lack of the data connected

with the phenomenon discussed in the article (in this case, with the phenomenon of dark matter, as mentioned in the text of the article) prevents the author from providing an explicit definition of the related theory-constitutive metaphorical expression. Nevertheless, describing the origin of the metaphorical expression "dark matter" enables him to convey to the readers the general idea of this phenomenon, which he then elaborates on in the remainder of his article.

Use of Theory-Constitutive Metaphors in the Biology Articles

As the analysis presented below will show, the ways and purposes of using theory-constitutive metaphors introduced into the texts of the biology articles are often similar to those observed in the texts of the articles dedicated to the questions of astronomy. At the same time, the results of the analysis suggest that, in some cases, theory-constitutive metaphors can be introduced into the text of the biology articles in some different ways compared to those used in the astronomy articles. The frequency of their use may also differ in these two varieties of PSAs.

The biology articles which were investigated in this study are aimed, first of all, to inform the reader about different physiological and behavioral characteristics peculiar to certain species of living beings. Some of them also familiarize non-specialist readers with some ecological factors and processes which may cause significant changes in the size of biological populations and in the genetic structure of some biological species. These phenomena are often described via the use of theory-constitutive metaphors (see Appendix A).

Unlike the astronomy articles, in the biology PSAs, the approximate frequency of theory-constitutive metaphorical expressions is only thirty metaphors per 1000 words. This tendency can be connected with the fact that many phenomena investigated and described by biologists have already been studied more thoroughly and thus are already understood better than some phenomena investigated by astronomers. This means that in many cases, biological phenomena

can be referred to and described with the help of other, non-metaphorical linguistic means as well.

In most cases, theory-constitutive metaphors are introduced into the biology articles to refer to the phenomena currently investigated in genetics or molecular biology, and especially to those denoting different functions and characteristics of DNA (e. g. *the (digital) code of life*, *text/book of life*, *translation*, etc.). Some of these metaphors are usually employed for presenting different characteristics of the immune system of some certain living beings (e. g. *neural networks, switching circuits, spin glasses, technology/machine* (in relation to organism), and so on). Occasionally the theory-constitutive metaphors identified in the biology PSAs are also used in the authors' descriptions of certain organisms and their habitats or characteristics (e. g. *seafloor*, *the animal kingdom*, *second-order/third-order alliances*, *host species*, etc.). As all these metaphors are used for presenting and describing the necessary concepts related to the subject of these articles, it is possible to say that they perform the informative function in them as well.

As well as in the astronomy articles, several forms of introducing theory-constitutive metaphors into the biology PSAs could be observed in the corpus of the study. All these forms are summarized below in Table 2.

Table 2.

Forms of Introducing Theory-Constitutive Metaphors into the Biology PSAs

Forms revealed in the biology articles	The number of occurrences in the corpus of the study	Examples
Based only on the context and the readers' world knowledge	26	"Although there are millions of different species of animals on the planet, perhaps the scariest of all are the creatures who live on the *seafloor*. These deep-sea creatures have made the lowest parts of the world their home, surviving thousands of meters below the surface." (Nosowitz, 2015)
Exemplifying/specifying the meaning of a new theory-constitutive metaphor	12	"*Building stones of life* – individual genes and alleles – make up different DNA sequences called genotypes." ()
Providing an explicit definition of the target metaphor	9	"Larger birds have relatively simple *wingtip paths*, that is circular patterns of rotating air left behind a wing as it generates lift." (Bryner, 2015)

Forms revealed in the biology articles	The number of occurrences in the corpus of the study	Examples
Using the elements of personification	8	"In many diseases, such as diabetes, *neural networks* play an important role in deciding who's going to get ill and how that happens." (Wolchover, 2015)
Explaining the etymology or origin of theory-constitutive metaphors	7	"Since those animal species harbor and provide sustenance for another organism, people tend to refer to them as '*host animals*'." (Seiff, 2015)
Providing a real-life story related to a certain scientific phenomenon	6	"Jacob and Brenner's proposed experiment required the help of Matt Meselson and his ultracentrifuges at Caltech in Pasadena. The challenge was to determine whether the *messenger* involved the creation of new ribosomes as Jacob and Monod had initially suspected, or instead consisted of a new transient form of RNA that simply

Forms revealed in the biology articles	The number of occurrences in the corpus of the study	Examples
		employed the old host ribosomes to turn its message into protein. After a tense month in California, endlessly fiddling with the experimental conditions (the magnesium concentrations proved decisive), Jacob, Brenner and Meselson finally got the experiment to work. As they had hoped, no new ribosomes appeared; instead, a small, transient RNA that had been copied from the phage DNA was associated with old ribosomes that were already present in the bacterial host. This was *messenger* RNA." (Mathewson, 2015)
	Total 68	

It is important that in this variety of articles, the reader who may not be a specialist in the subject of the article and who may not be familiar with the meaning of the theory-constitutive metaphors employed in the text of these articles is expected to infer their meaning based on their

prior and/or subsequent context and their previous knowledge connected with DNA, the immune system of living beings, and other phenomena which these metaphors may relate to. For example, when speaking about the mechanisms of resistance developed by cockroaches in response to increased radiation exposure, Seiff (2015) discusses some mutations which radiation causes in the cells of cockroaches. Before he mentions these mutations, he explains to the reader the role of DNA in terms of preserving the necessary hereditary information in the cells of living beings and the mechanisms of transferring that information from one organism to another: "Synthetic biologists have been attempting for years to expand on *the natural code of life* consisting of the nucleotide bases cytosine, guanine, adenine and thymine – also represented by the letters "C," "G," "A" and "T," respectively. So far, the potential additions they've tested suggest that, because radiation causes the most mutations in DNA that is replicating – which occurs most frequently in dividing cells – this slow replication protects roaches from radiation" (p. 97). In this fragment of the article, the author introduces the expression "the natural code of life" when referring to the information embedded in DNA and its different structural parts. Even though the article does not contain the exact definition or explanation of this metaphor, the reader who may not be familiar with this expression can easily infer its meaning from further context, including information about different substances comprising the structure of DNA and the author's explanation of the ways in which those substances can be represented with the help of the alphabet.

Similar to the astronomy articles, in those cases when the authors of the biology PSAs still assume that the readers may not know the meaning of theory-constitutive metaphorical expressions, they sometimes include their brief explicit definition in the text of their articles. For example, when comparing the structure of chromosomes in male and female chimpanzees and

human beings, Fawcett (2015) provides some general information about human genes as well: "Every gene in our body contains a *code*. The *code* is a kind of building description that is used for creating the building stones of the body, the proteins" (p. 57). It is interesting that in this case, the author defines the theory-constitutive metaphor "code" with the help of another theory-constitutive metaphoric expression ("building stones of the body") whose meaning the readers should be able to infer based on the context of the article and with the help of their world knowledge. Therefore, the author does not provide any definitions or additional details regarding the latter metaphor. At the same time, he assumes that, since its meaning should be clear to the readers based on the context of the article and their background knowledge, the use of this metaphorical expression should help the readers understand the meaning of the theory-constitutive metaphor "code" employed in different parts of the author's narration. This shows that the simultaneous use of several metaphors may help writers intensify and specify the meaning of the initial theory-constitutive metaphor.

It is also worth mentioning here that, although in the example cited above, the author does not provide an explicit definition of the expression "building stones of the body," he still makes it easier for the readers to infer its meaning, adding an example of the chemical elements which typically serve as the building stones of the body ("proteins"). Exemplifying this theory-constitutive metaphor makes its meaning specific and related to the subject of the article (that is, the structure of chimpanzees' and human genes and chromosomes), which, eventually, enables the readers to achieve an adequate understanding of the topics discussed in this article.

As well as the authors of the astronomy PSAs, in some cases, the authors of the biology articles show the origin of the theory-constitutive metaphors introduced into their articles. In his discussion of the artificial genetic polymers which might serve as an alternative to DNA,

Mathewson (2015) explains to the readers first why DNA and RNA are often referred to as the "molecular blueprints of life": "DNA and RNA are the *molecular blueprints of life*. They encode and pass on genetic information, known as heredity, and they can adapt over time, the process known as evolution. Without heredity and evolution, life would not exist" (p. 68). Making parallels between DNA or RNA and the phenomena of heredity and evolution allows the readers to understand why DNA and RNA are often called the "molecular blueprints of life." This also helps the readers to infer the necessary information about the major functions (e. g. encoding and passing on the necessary genetic information) which are typically performed by DNA and RNA in the genetic structure of humans and other living beings and which need to be performed by their artificial analogs as well.

Along with providing a brief explicit definition and exemplifying/specifying the meaning of theory-constitutive metaphors, occasionally some other forms of introducing this kind of metaphorical expressions can be used in the biology articles as well. In particular, in those cases when the text of the articles includes information about different elements of an organism and its genetic structure, new phenomena denoted via the use of theory-constitutive metaphors tend to be introduced with the help of personification: "The animal *cell* does not only remember from where it stems, but also where in the body it is located, and which function it has there… A skin *cell* preferably should remember that it is a skin *cell* so as not to after a number of cell-divisions start making proteins that are specific for, for example, liver *cells*" (p. 89). In this fragment, Yomtov (2015) describes the cell as having something similar to self-consciousness, since it seems to "know" its exact location in the body of a human being or animal. Using the verb "remember" which is normally associated with people and their mental capabilities or actions enables the author to describe the functions performed by different kinds of cells in the organism

of mammals in a vivid and illustrative way. This should also *motivate the readers to explore the subject of the article in more detail after they finish reading it. In addition,* stimulating the readers to associate certain people's characteristics and actions to human and mammals' cells with the help of personification should be helpful in terms of constructing coherent images in the minds of readers (Holmgreen, 2008). Thus, it is possible to assume that the use of personifications in the author's explanations of theory-constitutive metaphorical expressions appears to be advantageous because they allow a direct understanding of the necessary processes and phenomena which in such cases are seen in terms of human actions and motivations.

Presenting a real-life story associated with the phenomenon discussed in a particular article is another form of introducing new theory-constitutive metaphors observed in the biology PSAs. For example, in her article, Bryner (2015) describes in detail the researcher's encounter and relations with two dolphins whom she observes and whom she experiments with in her study of dolphins' communication with each other and with people in captivity and in nature. At some points, this description takes the form of a narrative telling the readers the story of the researcher's interaction with the dolphins, for example:

> The two dolphins that swim up to the boat are ones that Herzing has been hoping to encounter all week: Meridian and Nereide. Indeed, recordings of both dolphins' *signature whistles* have been preprogrammed into the CHAT boxes in the hope that Herzing might get a chance to greet the dolphins and interact with them. Since dolphins use distinct "*signature whistles*" to identify and call to one another, each dolphin was thought to invent a unique name for itself as a calf and to keep it then for life. (p. 91)

In this part of her article, Bryner introduces the theory-constitutive metaphor "signature whistles" when telling the readers about the procedure of the researcher's experiment which was

aimed at improving scientists' understanding of different kinds of signals employed by dolphins for identifying other organisms around them. From the story cited above, the readers can easily infer that the theory-constitutive metaphor "signature whistles" denotes the signals which are specifically used by dolphins for greeting and calling each other, as well as for attracting people's attention when living in captivity. Introducing the metaphorical expression "signature whistles" with the help of a real-life story makes the author's description of the related phenomenon informative, colorful and dynamic, as in this case it is enriched with the author's personal observations, impressions and associations connected with the subject of her article.

Discussion and Conclusions

As well as in other kinds of scientific discourse, along with the conventional metaphors which should be familiar to any member of the same linguistic community, the necessary scientific content is often delivered in popular science writing via so called "theory-constitutive metaphors." It follows from the results of the analysis presented in this chapter that the use of theory-constitutive metaphors in the text of the astronomy and biology PSAs investigated within this study is characterized by some common and varying features. As shown earlier, in the astronomy articles, it is possible to observe a more frequent use of theory-constitutive metaphors (approximately eighty metaphors per 1000 words), compared to the biology articles (approximately thirty metaphors per 1000 words). This tendency can be connected with the assumed degree of the readers' familiarity with the subject of these articles as well as with the current level of understanding of the phenomena studied by astronomers and biologists. In particular, many phenomena investigated and described by biologists have already been studied more thoroughly and thus are already understood better than some phenomena investigated by

astronomers. This means that in many cases, biological phenomena can be referred to and described with the help of other, non-metaphorical linguistic means as well.

As mentioned earlier, theory-constitutive metaphors are typically introduced in order to be adopted and developed by the relevant scientific community; in many cases, successful scientific metaphors become an essential part of the technical discourse of that community (Cameron, 2003; Semino, 2008). For example, based on the study presented in this chapter, it is possible to conclude that in most cases, theory-constitutive metaphors are introduced into the biology articles to refer to the phenomena currently investigated in genetics or molecular biology, and especially to those denoting different functions and characteristics of DNA (e. g. *the (digital) code of life*, *text/book of life*, *translation*, etc.). Some of these metaphors are usually employed for presenting different characteristics of the immune system of some certain living beings (e. g. *neural networks, switching circuits, spin glasses, technology/machine* (in relation to organism), and so on). To a certain extent, these observations can be related to Turney's (2013) conclusion, according to which genetics has probably generated the largest literature examining the use of metaphors. At the same time, he notes that beyond academia, science writers are especially conscious of the role of metaphors in communication around genetics. One of the main reasons for that is connected with the fact that those journalists who pay reasonable close attention to what is happening in the science of genetics, are also aware of the fact that ideas about genes, genomes and gene action are changing. Turney (2013) believes that this should stimulate them to be more careful when choosing appropriate metaphors connected with genetics and when using them in their actual popular science writing.

Likewise, Holton (1986), Christensen (2007), Khakhar (2017) and Scharf (2013) praise the role of certain metaphors in scientific development and/or in science writing, but at the same

time, all of them warn the readers of their guidelines of the risks embedded in the use of metaphors for the purposes of popularization, which may lead to a kind of "metaphor excess" in the case of choosing loopy metaphors or when mixing several metaphorical expressions at the same time. As demonstrated by Christensen (2007), the sentences including loopy metaphors do not make sense, for example: "George Orwell reports on the case of an MP who claimed that the jackbooted fascist octopus had sung its swansong" (p. 56). According to Christensen (2007), the use of several metaphors in a row in the sentence cited above ("… jackbooted fascist octopus had sung its swansong") leaves the readers misled and adrift, as it makes the meaning of the whole sentence vague and confusing.

Nevertheless, as mentioned by Bucchi (1998), metaphors allow scientific language to keep pace with rapidly changing theories. Perhaps it is the main reason why, according to Turney (2013), the authors of scientific and popular science texts continue to resort to theory-constitutive metaphors for referring and expanding on certain natural processes and phenomena in their writing. It is also considered that publishers of popular science literature look for clarity of expression from potential authors, – as well as a writing style that incorporates metaphors (Rayl, 1992). This can probably be explained by the fact that scientists themselves constantly resort to metaphorical expressions, similes and analogies, as sometimes it is the only way to convey the necessary content properly (Scharf, 2013). In addition, metaphors and analogies are considered useful because they distill the important components of a scientific idea; this allows non-experts to appreciate and understand the scientific content conveyed in a popular science text (Khakhar, 2017). This can be illustrated with the example from Khakhar's (2017) guidelines for science writers where the author of a popular science text provides various examples of the smells associated with the substances comprising space. While speaking about those smells, he

introduces several other novel metaphors which intensify and specify the meaning of the initial conventional metaphor ("a bouquet of hot metal, diesel fumes, and barbeque"), including such expressions as "aromas reminiscent of a charcoal grill," "smelling 'burned' or 'fried' steak after a space walk," "astronauts compared the smell of the moon to spent gunpowder," etc. With the help of these metaphors, the writer elaborates the ideas about different smells associated with space, which enables the reader to achieve an adequate and precise understanding of the subject of the article.

The contextual factors mentioned above (e. g. the current level of understanding of the phenomena studied by astronomers and biologists and the assumed degree of the readers' familiarity with the topic of PSAs) may also influence the ways of introducing the phenomena denoted by theory-constitutive metaphors into the text of the astronomy and biology articles. In particular, when a certain metaphorical expression is widely used by non-specialists and when its meaning can be easily inferred by the lay reader from the context of the article, those metaphors are often not accompanied by any additional details. On the contrary, in those cases when the readers may not know the terms, a brief definition of the phenomena denoted by theory-constitutive metaphors may be provided in the text of PSAs. As noted earlier, in the astronomy articles, the concepts conveyed via the use of theory-constitutive metaphorical expressions are often defined and/or explained (in most cases, within one sentence, either before or after introducing the target metaphor). Although some theory-constitutive metaphorical expressions introduced into the text of the astronomy articles have spread into common usage too, in many other contexts not connected with astronomy (e. g. in fiction or in the texts dedicated to the questions of art, politics, economics, healthcare, etc.), they have developed more conventional metaphorical meanings different from those in the texts about astronomy. This observation

matches the findings of Domínguez (2015), Hellsten and Nerlich (2011), Knudsen (2005), López (2007), Maasen and Weingart (1995), and Semino, Deignan, & Littlemore (2013) which suggest that the very same metaphorical expressions hold different status within different scientific and non-specialist discourse communities at different times and that this status or level of metaphoricity is reflected in the actual use of genre and language. In addition to the fact that the phenomena denoted by the theory-constitutive metaphors employed in the astronomy PSAs may not be familiar to the lay reader, the use of those metaphors in some other meanings within other discourse communities may be another reason why, as shown in Table 1, the theory-constitutive metaphors introduced into the astronomy PSAs are defined or explained more often, compared to the metaphors employed in the biology PSAs.

Unlike the astronomy articles, in the articles dedicated to the questions of biology, the meaning of the theory-constitutive metaphors which are used in them can often be inferred only from the prior/subsequent context of the article and/or the related illustrations accompanying the text of that article. This tendency is probably connected with the fact that, as noted earlier, in most cases, the phenomena denoted by these metaphors in the articles about biology are supposed to be better familiar to the lay reader than those in the astronomy articles. In many cases, the theory-constitutive metaphors introduced into the biology articles may be perceived both by specialists and by the general public as non-metaphorical expressions, since, unlike most of the metaphors introduced into the astronomy articles, many theory-constitutive metaphors encountered in the biology articles (e. g. “cells” (in relation to the organism of living beings), “the animal kingdom,” “book of life,” “building blocks,” “neural networks,” “signature whistles” (in relation to dolphins), etc.) have become conventionalized not only within particular scientific communities but in society in general. At the same time, most of the theory-constitutive

metaphorical expressions identified in the biology articles are used in relation to current research in genetics and molecular biology where appropriate non-metaphorical terminology for denoting certain scientific phenomena (for example, different functions and characteristics of DNA) may not have been developed yet. As suggested by Pramling and Säljö (2007), using metaphorical means of denoting such phenomena serves a bridging function by connecting what is to be understood to something familiar. This increases the possibilities for the readers to apply previous knowledge as a resource for understanding. Nevertheless, similar to the astronomy articles, in those situations when the potential readers may not be able to understand the meaning of the theory-constitutive metaphors employed in their texts based on their prior/subsequent context, brief explicit definitions of those metaphors are sometimes included in those articles as well. As shown earlier, in some cases, these definitions may contain the instances of other theory-constitutive metaphorical expressions whose meaning can be inferred based on the information conveyed in the article and/or the readers' background knowledge.

Along with providing a brief definition of the target theory-constitutive metaphors, in some cases, their etymology or origin can also be explained in the text of PSAs; this should allow the readers to understand the reasons for using those metaphorical expressions when referring to certain scientific phenomena. As shown by Lazarevich (1978), by using this method of introducing new theory-constitutive metaphors (and new scientific terms in general), writers can suggest new associations, thoughts, and ideas related to the concepts denoted by those terms. Eventually this should make one's understanding of the scientific information presented in PSAs deeper and more effective.

The evidence found also shows that, in some cases, other forms of introducing new theory-constitutive metaphors are specifically used in the astronomy articles but not in the

biology PSA. For example, in the articles dedicated to the questions of astronomy, several other forms of introducing the phenomena denoted by this kind of metaphor were revealed as well, including:

- using the word "called" when introducing a new theory-constitutive metaphor;
- mentioning one or two features or characteristics of a scientific phenomenon;
- sharing with the readers the author's evaluations and other additional details connected with a certain phenomenon;
- comparing a scientific phenomenon with another process or phenomenon familiar to the general public;
- providing the explanations of a scientific phenomenon suggested by different scientists.

As shown in previous research into the language of popular science texts (e. g. Gantt, Melling, & Reber, 2012; Hyland, 2010; Lazarevich, 1978; Leydesdorff & Hellsten, 2005; Maasen & Weingart, 1995), some of these forms of introducing new theory-constitutive metaphors and other scientific terms (namely, using the word "called," mentioning a feature or characteristic of some group of species denoted by a certain term, and providing the explanations of a scientific phenomenon suggested by different scientists) are widely used in different kinds of popular science and popularized texts. At the same time, some other forms of introducing theory-constitutive metaphors (such as sharing with the readers the author's evaluations and other additional details connected with a certain phenomenon or comparing a scientific phenomenon with another process or phenomenon familiar to the general public) are more peculiar to the texts of the astronomy PSAs, where they are typically employed for conveying the necessary scientific content in an informative and illustrative way.

The results of this analysis also showed that, compared to the astronomy articles, the biology PSAs investigated in the present study are characterized by a smaller range of the forms of introducing new theory-constitutive metaphors. This tendency is probably connected with the fact that, as mentioned earlier, the meaning of the theory-constitutive metaphors employed in the biology PSAs can often be inferred based on the context of the article and the readers' world knowledge. Nevertheless, in some cases, several additional methods of introducing this kind of metaphor, which are not typical of the astronomy articles investigated in this study, can be observed in the articles dedicated to the questions of biology as well, namely:

- exemplifying/specifying the meaning of a new metaphorical expression;
- using the elements of personification;
- providing a real-life story related to a certain scientific phenomenon.

Exemplifying and/or specifying the meaning of new theory-constitutive metaphors and other scientific terms *t*ends to make the author's explanations coherent and hence accessible to non-specialist audiences (Adamsone-Fiskovica, 2015; López, 2007; Miller,1985; Parkinson & Adendorff, 2004; Pramling and Säljö, 2007). At the same time, the *presence of the elements of personification* in the explanations of new metaphorical expressions introduced into the biology PSAs makes the necessary scientific content illustrative and coherent. This corresponds with the findings of some previous related studies (e. g. Molek-Kozakowska, 2016; Valiverronen & Hellsten, 2002; Wingens, 1990), according to which the use of personifications and some other linguistic and stylistic devices (e. g. clichés, phraseological units, colloquial and evaluative vocabulary) in the text of popular science texts makes scientific narration vivid, persuasive and engaging to non-specialist audiences. Finally, as shown earlier, introducing a new theory-constitutive metaphorical expression via a story related to the phenomenon denoted by it signals

the readers that the questions discussed in them are interesting and up-to-date. The results of some previous studies (e. g. Camus, 2009; Dahlstrom & Ritland, 2014; Holton, 1986) suggest that stories are easier to comprehend; in addition, readers typically find them more engaging than traditional logical-scientific communication. Furthermore, the use of stories in PSAs and other kinds of popular science texts makes scientific explanations less abstract and more concrete (Chernyavskaya, 2004). Thus, it is possible to conclude that providing a story related to a certain scientific phenomenon allows the authors of PSAs to balance their dual goals of reporting objective and accurate factual and scientific information in a dynamic and engaging way.

The differences revealed in terms of the frequency and ways of applying and introducing theory-constitutive metaphors into the two varieties of the articles investigated in this study show that the use of this kind of metaphorical expression in the texts of PSAs may correlate with their subject. In this connection, it is possible to conclude that the subject of PSAs needs to be regarded as one of the contextual factors having influence on the use of theory-constitutive metaphors in the text of PSAs. However, as demonstrated earlier, in spite of some variations observed in terms of the forms and frequency of introducing theory-constitutive metaphors into the astronomy and biology articles, some other methods of introducing new metaphorical expressions are commonly applied in both varieties of PSAs. Besides, in all articles analyzed within this study, the use of theory-constitutive metaphors is aimed, first of all, at presenting certain scientific phenomena and their particular aspects. In this connection, we can conclude that in both varieties of PSAs, theory-constitutive metaphorical expressions mainly serve the informative (cognitive) function. The existence of these invariant characteristics lets us make sure that, despite some differences in the ways of using and introducing new theory-constitutive

metaphors observed in the biology and astronomy articles included in the corpus of the study, all these texts belong to the genre of popular science article.

In the future, further research into different ways of introducing theory-constitutive metaphors and other kinds of metaphorical expressions (including conventional/novel metaphors and personifications) into the texts of printed and online PSAs dedicated to different subjects and fields of study would be desirable for getting a better understanding of various trends observed in the use of metaphor in this kind of popular science text. At the same time, a more active use of the COCA and other corpus tools could be useful for comparing the range, frequency, and ways of using theory-constitutive and other types of metaphor in various structural parts of PSAs and in some other kinds of popular science and popularized texts (including the texts of science blogs, editorials, popular science books, etc.). Conducting such research would make it possible to reveal characteristics differentiating PSAs or any other particular genre of popular science literature from some other kinds of popular science literature. Finally, further research into the use of metaphor in the popular science texts dedicated to different subjects and/or published in different magazines or on different Web-sites would be useful for revealing various contextual factors which may influence the use of metaphor in the actual discourse. Later the findings of such research could be used for creating the guidelines for science journalists and scientists writing PSAs and other popular science texts. In addition, the results of that research could also be incorporated then into the system of EFL/ESL and especially ESP or science teaching (for example, for teaching students how to use metaphor for explaining the necessary things in an adequate way, for making science interesting and accessible to students, etc.). This shows the importance of further research into the use of different kinds of metaphor in the text of PSAs.

CHAPTER III

ON THE USE OF SIMILE IN THE TEXT OF POPULAR SCIENCE ARTICLES

Introduction

Although, as shown in Chapter 2, theory-constitutive metaphors play an important role in providing vocabulary resources applied to different scientific phenomena, they still do not exhaust all manifestations of metaphoricity in the text of PSAs. As mentioned earlier, along with the factual information connected with the research discussed in the article, the texts of PSAs also contain the elements of evaluative and emotional information, including the author's and researcher's opinions, judgements and assumptions connected with the subject of the article. According to some previous research (e. g. Darian, 2000; López, 2007; Semino, Deignan, & Littlemore, 2013; Valiverronen & Hellsten, 2002), the necessary factual or evaluative information can be conveyed in the text of PSAs and in other types of science popularization via some other kinds of metaphor as well, including conventional and novel metaphors as well as personification and animation. As well as theory-constitutive metaphors, all these types of metaphor are based on using a word or phrase which is applied to something to which it is not literally applicable (Domínguez, 2015). For example, in the conventional metaphorical expression "food for thought" where the noon "food" is used together with the noun "thought," their meanings do not have any logical connections with each other before these nouns are combined together in this expression to refer to something important and thought-provoking.

At the same time, it was demonstrated in several studies (e. g. Chiappe, Kennedy, & Smykowski, 2003; Darian, 2000; Gentner & Bowdle, 2005) that another type of linguistic device that is intensively used in popular science texts, including the texts of PSAs, is simile – an explicit statement of comparison between two different things which are conveyed through the use of expressions such as "like," "as," "as if," and so on (Semino, 2008). According to Vengadasamy (2011), figurative references such as similes are fundamental in science popularizations, as they can stimulate the audience's imagination, transforming the learning experience into a pleasant event. This way they also create a sense of proximity between the authors/speakers and the audience (Hezaveh, 2014).

As well as in other kinds of science discourse, in popular science writing, simile is important because most productive theorizing involves the use of analogies which can play an important creative role in structuring problems of research and professional practice in different areas of science (Dunn, 1980). In this connection, it is logical to assume that similes can be used in PSAs for conveying the necessary factual information, including presenting and explaining the necessary scientific phenomena, scientific issues or advances and new understandings of those phenomena which were studied and discussed in certain areas of science earlier as well. Besides, the presence of the markers of an explicit statement of comparison in the structure of similes ("like," "as if," "as though," etc.) makes them an effective tool for making unfamiliar things more similar or a familiar thing more unique (Darian, 2000).

The results of some previous research (Bucchi, 1998; Holton, 1986; Keller, 1995; Leary, 1990; Semino, 2008) suggest that including simile in science popularizations also enables their authors to describe and promote their own views, attitudes and opinions related to the subject of discourse in a convincing, accessible and vivid way. So it is possible to conclude that the use of

simile should help the authors of PSAs and other popular science texts convey the necessary factual and evaluative information to the lay reader in an accessible and entertaining way.

Although the research into the use of simile in popular science communication in general prevails in previous literature, in several related studies, the researchers' primary purpose was to investigate some features of similes and the trends observed in their use in a certain genre of popular science literature. The results of such studies, including the analysis of TED talks (Caliendo & Compagnone, 2013; Scotto di Carlo, 2014), web-based popular science texts (Caliendo, 2012), and popular science TV programs (Wikberg, 2008), suggest that introducing simile into popular science texts allows their authors to compare complex scientific concepts to everyday life experiences, and thus to breach the expert/non-expert barrier so that non-experts can participate in the scientific findings. In this connection, the researchers conclude that the use of simile in science popularizations can be regarded as an explanatory strategy for knowledge dissemination stimulating the general public to look at science as ideas to be discussed rather than information to be passively received (Hyland, 2010). In addition, as noted by Matoesian (1999), the analysis of similes as a popularizing strategy can give researchers an insight into the construction of discursive identities in interactions between experts and non-experts. This shows the importance of investigating the use of simile in some other kinds of popular science literature as well, including PSAs. Noteworthy, as shown in Moder (2008), the relationship between simile and various contextual factors determining their use in a particular genre can be fully understood only if the former is studied in its authentic and naturally-occurring discourse contexts. It means that examination of simile in its actual discourse content should allow us to reveal similarities and differences in its use in the text of the PSAs published in different sources.

At the same time, it was demonstrated in several recent studies that the use of corpora and corpus tools can help the analyst conduct more focused and in-depth studies aimed to investigate the use of metaphors (Hardie, Koller, Rayson, & Semino, 2007), personifications (Skorczynska & Ahrens, 2015), similes (Chiappe & Kennedy, 2000; Scotto di Carlo, 2014), and some other stylistic devices (e. g. Aasheim, 2012; Durán-Escribano & Cuadrado-Esclapez, 2017; Hussein & Sawalha, 2016) in the texts belonging to various genres and written in different languages. It follows from the results of these studies that the use of corpora and corpus-based tools allows researchers to reveal and examine different quantitative and qualitative variations in the use of these devices. In particular, having them at their disposal enables analysts to investigate the relative frequency of their use in different instances and varieties of the same and different genres, the influence of different contextual factors on the frequency and ways of using them in a particular genre, their grammatical and lexical structure, etc.

In this connection, it is possible to assume that more in-depth corpus-based studies need to be conducted for improving our understanding of the ways in which simile may influence the processes of inferring and constructing the necessary meanings delivered in concrete genres, including the genre of PSAs. Therefore, the study discussed in this chapter was aimed at addressing the following research question: in what way does the source where a particular PSA is published determine the lexical structure, functions and frequency of using simile in the text of PSAs from different magazines (namely, *National Geographic* and *Discover*)?

Thus, the main purpose of the study described in this chapter was to analyze the use of similes in the text of the PSAs which are dedicated to the same subject (namely, ocean life research) and which are published in two different magazines. At the same time, as noted by Scotto di Carlo (2014), similes are the most suitable figurative element in terms of their study

through corpora analysis, as they can be adequately sampled because of their simple and quantitatively retrievable syntactic pattern. Therefore, it is possible to conclude that the analysis of the relevant data provided by a specialized corpus of the PSAs published in different sources (with the use of appropriate search tools and concordances) should help us arrive at a better understanding of various contextual factors which may influence the use of simile in this kind of popular science writing. Besides, comparing the texts of the articles from two different magazines which are dedicated to the same subject but which are intended for different categories of non-specialist audiences should let us understand whether specific characteristics and requirements of a concrete magazine may have some influence on the ways of using simile in the text of a particular PSA. With the help of the results obtained in this study, I hope to be able to identify and provide a systematic description of some important peculiarities of applying this stylistic device in this kind of popular science writing.

Research Design

In order to be able to analyze the use of similes in PSAs in their authentic and naturally-occurring discourse contexts, the method of corpus analysis was applied in this study. The evidence presented in this paper was collected from a specialized corpus constructed for the purposes of the study (although later it could also be used for investigating the use of other linguistic and stylistic devices introduced into the text of PSAs). All articles included in this specialized corpus are about ocean life research. Their main purpose is to familiarize the readers with scientists' new findings about the physiological and behavioral peculiarities of certain biological species living in seas and/or oceans (the articles focusing on the use of technology for ocean life research or on any other topic not directly connected with the biology of marine

organisms were excluded from the corpus of the study). The articles investigated in this part of the dissertation project were written either by science journalists or, in some cases, by the experts in the fields related to the subject of the articles. Originally these articles were published in different issues of the US printed magazines *National Geographic* (the first 23 articles analyzed in this study; 26,166 words in total) and *Discover* (the other 16 articles investigated in this study; 26,302 words in total). Each of the 39 articles included in the corpus of this study (see the References) was taken from a different issue of one of these two magazines published during the period between 1993-2017. Based on the source where these articles were originally published, the corpus was divided into two subcorpora. A different number of articles in each subcorpus was connected with the necessity to have the subcorpora of a similar size. This should have made the corpus employed in the present study more balanced and more representative. The number and size of the articles included in each subcorpus of the study also corresponds with Biber's (1993) recommendations to include at least 1,000 words and "at least five, if possible ten, different samples" (p. 70) for a sub-corpus containing a specific genre or text type.

Another important factor which should have made the corpus constructed for this study more representative is the choice of the data sources. The two magazines mentioned above were chosen because they are intended for different categories of readers. According to the information provided on the Web-site of *National Geographic* (http://press.nationalgeographic.com/2012/09/24/national-geographic-shows-30-9-million-worldwide-audience-via-consolidated-media-report/), the articles and other materials published in this magazine are intended for non-specialist target audiences, which means that the readers of these articles can be people of different age, having different educational background and different degree of familiarity with their subjects. As this magazine contains not only the

articles dedicated to the questions of science but also some materials on the questions of history, economics and world culture, some readers of this magazine may not be interested and/or may not be familiar with certain areas of science discussed in some of its articles.

The *Discover* Web-site (http://discovermagazine.com/~/media/Files/PDF/Advertising/2013/DSC-MediaGuide2014v5.pdf) indicates that the materials of this magazine are intended for the people interested in biology, astronomy, physics, and/or chemistry as well as in a wide range of areas of the natural sciences in general (e. g. anatomy, physiology, ecology, geography, geology, etc.). Compared to *National Geographic*, the potential readers of this magazine should be already familiar with certain areas of science (and with science in general) by the time they start reading *Discover*. Thus, using this corpus for the purposes of the study should help us understand whether the target audience of the articles published in different magazines and some other contextual factors (including the requirements of the source where this or that text is published, communicative and pragmatic purposes of the author of a concrete text, the topic of a certain article, etc.) may influence the lexical structure, functions and frequency of using simile in the text of the articles aimed to convey the necessary scientific information and ideas to different categories of non-specialist audiences.

Similar to the study described in Chapter 2, identification of the similes in the text of the PSAs included in the corpus of the study was based on the use of the metaphor identification procedure (MIP) (Pragglejaz Group, 2007). However, before coming to the stages of the procedure itself (see the "Research Design" section of Chapter 1), it was necessary to identify in the text of the articles investigated in this study all expressions containing the elements of comparison marked by "like" (including "noun + like" combinations), "as," "as if," or "as though"). To be able to do it more quickly and more effectively, AntConc software (Anthony,

2014) was used. AntConc is a freeware concordance program developed by Prof. Laurence Anthony, Director of the Centre for English Language Education, Waseda University (Japan). This freeware corpus analysis toolkit is intended for concordancing and text analysis; it is used for analyzing electronic texts in order to find and reveal patterns in language. In particular, this software allows for word and keyword frequency generation, concordance distribution plots, and tools for clusters, n-grams, and collocate analysis.

In the study discussed in this chapter, for each of the two subcorpora, all expressions containing the above-mentioned comparison markers were automatically identified with the help of the Concordance option of AntConc software. Using those comparison markers as search terms, it was possible to receive the list of the expressions from each subcorpus, containing one of those markers. Attributing the expressions containing those markers of comparison to similes (that is, to metaphorical comparisons) and to traditional, non-metaphorical comparisons was based on using the main stages of the MIP described above for analyzing each element of the expressions of comparison identified in each subcorpus. The lexical structure of each of those expressions (e. g. whether they include only stylistically neutral lexical units or if they also contain some stylistically colored elements, such as evaluative adjectives, colloquial words or expressions, the adverbs “very,” “too,” “overly,” “much more,” etc.) was analyzed with the help of the Collocates option. Information about the context in which each of the similes revealed in the corpus was actually used was obtained with the help of the File View option available in AntConc software as well. In those cases when the contextual meaning of at least one element of an expression of comparison contrasted with the basic meaning but could be effectively understood in comparison with it, such an expression was regarded as an example of simile. Those expressions of comparison in which the contextual meaning of all elements did not

contrast with their basic meaning were considered non-metaphorical and thus were not attributed to similes. For instance, in her PSA, Kaufman (2005) makes the following comparison about one of the crabs which she saw during her trip to Komodo: "He could afford to stick out *like a beacon* because the something he was sitting on was his form of defense – a stinging hell's fire anemone" (para. 3)[4]. In this sentence, the word "beacon" in the comparative construction "like a beacon" can be coded as metaphorical, as its basic and contextual meanings contrast with each other and as its contextual meaning can be inferred from its basic meaning. In particular, according to the online Webster Dictionary (http://www.merriam-webster.com/dictionary/), a beacon is "a signal fire commonly on a hill, tower, or pole; a lighthouse or other signal for guidance; a radio transmitter emitting signals to guide aircraft." At the same time, in the context of the article, the word "beacon" does not relate to any concrete signal fire, lighthouse or radio transmitter, but is used for showing similarity of the outward appearance of that crab which the author saw in Komodo to that of a beacon. Therefore, in the context of the sentence cited above, it is possible to attribute the expression "like a beacon" to a simile.

The method of contextual analysis was used for determining whether a certain simile is mostly used for conveying factual or emotional/evaluative information and whether it performs the informative (cognitive) or evaluative function in a particular context. In this study, those similes which are used by the authors of PSAs to point to a particular characteristic of a certain object or phenomenon or which are mainly aimed at showing the logical connections between the concepts and notions introduced into their articles with the objects and phenomena familiar to the lay readers were considered to perform the informative function. Such similes mainly (but not always) consist of stylistically neutral lexical units. According to Chiappe, Kennedy, and

[4] In this and all other examples from the text of PSAs cited in this chapter, similes have been italicized by me.

Smykowski's (2003) research findings, the similes are mainly used for conveying certain factual information when they include:

- stylistically neutral nouns;
- stylistically neutral adjectives;
- abbreviations or scientific terms and their synonyms; and
- colloquial words.

Based on these researchers' observations, all similes which were found in the corpus of this study and whose lexical structure includes any of these elements were coded as the similes performing the informative function in the text of PSAs. For example, when describing some technologies and procedures employed in the process of studying deep-sea organisms, Bosveld (2009) mentions the following: "Using special diving suits and submersibles, they have even entered the habitat of deep-sea organisms, watching in awe as the water world lit up with bursts of color that sparkled *like fireworks*" (para. 5). In this case, comparing the light emitted by deep-sea organisms with fireworks allows the author to show the readers what that light produced by deep-sea animals actually looked like. The simile "like fireworks" does not contain any elements of evaluation or emotion, but its use helps the author describe one of the features of the phenomenon described in her article in a clear and accessible way. Therefore, it is possible to conclude that this simile is used in this article for conveying the necessary factual information and that it serves the informative function.

At the same time, those similes which are mostly used for expressing the author's position towards the questions discussed in his/her article were regarded as the ones performing the evaluative function in the text of a certain article. According to Darian (2000), the similes

including the lexical elements enlisted below mainly serve the evaluative function in oral and written communication:

- evaluative adjectives;
- lexical intensifiers;
- mitigating devices (hedges);
- word repetitions; and
- elements of exaggeration.

In accordance with these researcher's findings, the similes which were revealed in one or both subcorpora of this study and which include any of these stylistically colored lexical elements were attributed to the similes performing mainly the evaluative function in the text of PSAs. For instance, in his article about one of the rarest marine mammals called "vaquitas," Welch (2015) mentions that the vaquita were in decline because they drowned in nets as the fishing industry chased totoaba, a critically endangered fish whose swim bladder was considered a delicacy in Asia: "Taylor was told that totoaba bladders were so hot that they could be purchased and stored in a safe in China and held *like a precious metal*" (para. 3). In this fragment of the article, the author conveys his point of view about the importance of totoaba bladders for Asian people. Including the evaluative adjective "precious" in the simile "like a precious metal" indicates those people's positive attitude to the taste of the dish prepared with the use of totoaba bladders. Thus, it is logical to assume that the simile introduced into the sentence cited above mainly performs the evaluative function.

In addition to the qualitative analysis of the use of simile in PSAs, the normalized frequency (per 1000 words) of using the similes serving the informative and evaluative functions and having a different lexical structure was calculated and compared in both subcorpora for

enhancing the qualitative data obtained within this study. To calculate the density of the similes performing one of these functions in each variety of PSAs, the formula for multi-word expressions presented in the "Research Design" section of Chapter 2 was used in this study too. In accordance with this formula, the total number of individual words within the similes performing the informative or evaluative function and having a different lexical structure (e. g. the similes containing colloquial words or expressions, evaluative adjectives, lexical intensifiers, scientific terms, etc.), which were revealed in the articles investigated in this study, was divided by the number of words in the whole subcorpus of the articles belonging to the same variety of PSAs; then the resultant number was multiplied by 1000 (similar to the study described in Chapter 2, the data about the frequency of using similes in the text of PSAs, which are presented in the Data Analysis and Findings section of this chapter, were rounded off to two decimal digits).

The process of calculating the frequencies of introducing similes into each subcorpus involved the use of the UAM Corpus Tool (O'Donnel, 2016) – annotating software that is able to automatically annotate the grammatical structure and parts of speech of the text; it also allows manual annotation of linguistic features based on various schemes. The use of the UAM Corpus Tool in the process of conducting this study allowed me to sort out the similes having a different lexical structure in a less time-consuming and more productive way. In particular, using the Search option available in this application helped me identify in the list of the similes revealed in the corpus of this study the expressions of comparison containing, for example, evaluative, colloquial or stylistically neutral adjectives and nouns, lexical intensifiers, scientific terms, etc. (see Appendix B). For instance, after applying the formula [tag="adv *"][word="like"] when using the Search option of the UAM Corpus Tool, it was possible to identify the similes having

the comparison marker “like” and containing one or more adverbs; then it was possible to choose manually from that new list the similes with the adverbs which could be regarded as lexical intensifiers. At the same time, applying the formula [tag="adj *"][word="as"] enabled me to get the list of the similes with the comparison marker “as,” containing evaluative, stylistically neutral or colloquial adjectives. Then it was possible to choose manually the similes containing each of these types of adjectives. The same procedure (with the necessary changes in the formulae employed for this automatic search) was applied in the process of extracting and counting the number of similes with different comparison markers, containing any other kind of stylistically neutral or stylistically colored lexical elements. After that, it was possible to calculate the normalized frequency of using the similes with a different structure in both subcorpora analyzed in this project. Calculating and comparing in each of the two subcorpora the frequency of similes serving the informative or evaluative function and having a different lexical structure enabled me to determine in which of these two varieties of PSAs this kind of stylistic devices is employed more often and what function it mostly performs in each of them.

Data Analysis and Findings

Analysis of the Similes Performing the Informative Function in the Text of the PSAs Published in *National Geographic* and *Discover*

The analysis suggests that the authors of the PSAs from both subcorpora investigated in this research project resort to simile when providing some additional explanations aimed at improving the reader’s understanding of the phenomena described in their articles. As in this case similes can be used for conveying some elements of the factual information related to the subject of the article, it is possible to say that in many cases, they mainly serve the informative function. An example of the simile performing the informative function which is cited below was

taken from Parker's (2015) PSA. In this article, she presents different factors and scenarios which may have caused the disappearance of numerous marine megafauna species at the end of the last Ice Age. Closer to the end of the article, the author provides some examples of the animals who went extinct at that time: "For example, when gomphotheres, a large *elephant-like creature*, went extinct in South America about 9,000 years ago, the delicate balance of the region's underwater food chain was devastated" (para. 12). The use of the simile "elephant-like creature" accompanied with the adjective "large" enables the author to tell the readers about the size and appearance of those extinct animals in a memorable and illustrative way, without using numbers or any other exact data, which would make it more difficult for the reader to infer the necessary information from this description (although we should acknowledge that omitting the exact data can potentially result in mystification and oversimplification of scientific content).

Calculating the normalized frequency of the similes used in their informative function showed that the authors of the articles published in *Discover* tend to use similes for conveying the necessary factual information more often that the authors of the articles from *National Geographic* (18.44 per 1000 words in the articles from *Discover* vs. 13.36 per 1000 words in the articles published in *National Geographic*). This tendency can be connected with the assumed degree of the readers' familiarity with the subject of the articles published in these two magazines. In some cases, this factor may have also influenced the lexical structure of the similes introduced into the text of PSAs. Different variations observed in the lexical structure of the similes performing the informative function and their normalized frequencies in the corpus of the study are enlisted below in Table 3.

Table 3.

Normalized Frequencies of Using the Similes with a Different Lexical Structure, Performing the Informative Function in the Text of PSAs

A characteristic element of the lexical structure of similes	PSAs from *National Geographic*	PSAs from *Discover*	Examples
Only stylistically neutral nouns (either with or without articles)	7.03	10.20	"Coral reefs are as essential for oceanic animals *as if they were <u>the lungs of the ocean</u>*[5] [6]." (Kaufman, 2005)
Stylistically neutral adjectives	3.02	6.08	"Ocean krill can often be *as <u>busy</u> as a bee*." (Gallo, 1993)
Synonyms of scientific terms	2.47	–	"As soon as jellyfish happens to be out of the water, it becomes *as slick as snot on a <u>goat</u>'s glass eye*." (Langley, 2017)

[5] In this and all other examples from the text of PSAs cited in Tables 3 and 4, similes have been italicized by me.
[6] In this and in all other examples from the text of PSAs cited in Tables 3 and 4, the characteristic elements of the lexical structure of similes (e. g. well-known scientific terms, colloquial words, evaluative lexical units, word repetitions, etc.) have been underlined by me.

A characteristic element of the lexical structure of similes	PSAs from *National Geographic*	PSAs from *Discover*	Examples
Colloquial words	1.32	1.14	"Herrings' whitebaits seem to bring *as much fun as a sackful of cats*." (Howard, 2015)
Well-known scientific terms and acronyms	1.08	1.20	"A lonely humpback whale exploring the food stores available on the seafloor is *like a rubber-nosed woodpecker in a petrified forest*." (Groc, 2015)
Total	13.36	18.44	

As follows from the data summarized in Table 3, the results of the analysis show that in the articles from both subcorpora investigated in this project, the similes containing only stylistically neutral nouns (either with or without the definite or indefinite article) comprise most of the similes performing the informative function there (10.20 per 1000 words in *Discover* and 7.03 per 1000 words in *National Geographic*). For example, when describing different

underwater ocean plants located at the bottom of the food chain, Amato (2014) draws the readers' attention to the most important characteristics of their anatomy: "Diatom exoskeletons, made of silicon dioxide, sometimes seem like tiny, ornate pillboxes, with one half fitting into the other half. Some look *like mandalas*" (para. 6). In this case, comparing diatom exoskeletons with mandalas allows the author of the article to describe their shape and size in a compact and illustrative way. Including in the fragment cited above another simile ("like tiny, ornate pillboxes") makes the author's narration even more vivid and dynamic, which should help him attract and maintain the readers' attention throughout the whole text of the article.

While the articles published in *National Geographic* and in *Discover* are characterized by the frequent use of the similes containing only stylistically neutral nouns, in the articles from *Discover*, their authors often convey the necessary factual information with the help of the similes containing stylistically neutral adjectives as well. For instance, in his article about ocean predators, Svitil (1998) compares *hydroids* (a life stage for most animals of the class Hydrozoa, small predators related to jellyfish) with some other forms of life: "Over the years the National Marine Fisheries Service has also surveyed Georges Bank. But they always considered hydroids a nuisance – they stick together and get in the way of everything else you are trying to count, *like small crustaceans*" (para. 3). The use of the stylistically neutral adjective "small" allows the author to draw the readers' attention to a particular characteristic of the organisms described in the article (namely, the size of hydroids). This example also shows that employing the similes pointing to the most important characteristic(s) of the objects and phenomena described in PSAs allows their authors to convey the necessary scientific information in a dense and compact form, not overwhelming the lay reader with too many details or unnecessary information.

Prevalence of the similes containing stylistically neutral adjectives in the articles from *Discover*, compared to those from *National Geographic* (6.08 per 1000 words in *Discover* vs. 3.02 per 1000 words in *National Geographic*), can probably be explained by the fact that the articles published in *Discover* usually contain more factual information related to their subject. Interestingly, the similes introduced into the articles from *Discover* may contain more than one mentioning of the same characteristic of a certain species or phenomenon. For example, in the article "Bright Pink Sea Slugs Invading New Habitats Due to Global Warming?" analyzed in this study, Landhuis (2015) makes the following comparison about megafauna: "These megafauna – by definition any animal weighing more than 100 pounds – included some of the most bizarre beasts ever to inhabit the earth: glyptodons, *huge armadillo-like mammals the size of a Volkswagen Beetle*…" (para. 4). The author conveys the necessary information about the size of glyptodons with the help of the adjective "huge." At the same time, using the word combination "of a Volkswagen Beetle" in the simile cited above enables the author to describe the size of glyptodons in an illustrative way. This should probably help the readers form a more colorful and hence more memorable mental image of the outward appearance of glyptodons.

While the articles from *Discover* include many examples of the similes containing stylistically neutral adjectives and indicating some particular characteristics of certain objects and phenomena, several similes revealed in the articles from *National Geographic* include the synonyms of some scientific terms which should be already familiar to the readers before they start reading the article. For instance, when introducing the term *rostrum* into his article about communication between dolphins and people, Foer (2015) uses the word "beak." The latter has a more general meaning and is often employed in different kinds of texts and discourses, but not only in scientific communication: "Having scanned the ocean bottom with echolocation to find

hidden fish, a dolphin off the coast of Bimini in the Bahamas goes vertical, digging the fish out of the sand with its rostrum, which extends its mouth *like a typical bird's beak*" (para. 3). Introducing the simile containing a more conversational variant of the scientific term mentioned in the text of the article points to the fact that including the synonyms of scientific terms in the similes employed in PSAs helps their authors make their content clear and accessible to non-specialist audiences. It is also important to mention here that while the normalized frequency of the similes from the PSAs published in *National Geographic*, which contain the synonyms of scientific terms, was 2.47 per 1000 words, while in the PSAs published in *Discover*, such similes were not revealed at all. This can be connected with the fact that the authors of the PSAs published in *National Geographic* need not only to present the necessary scientific content in an accessible way, but they should also motivate the readers of their articles who may not have enough experience of reading about science to start and continue reading the text of the article. As the example cited above suggests, the use of the similes containing the synonyms of scientific terms can be regarded as one of the devices which can be applied by the authors of PSAs for making their content clear to the general public.

It is interesting that, although the similes containing the synonyms of scientific terms were revealed only in the articles from *National Geographic*, it was still possible to identify a few examples of the similes containing colloquialisms in the text of the PSAs from both magazines analyzed in this study (1.14 per 1000 words in the articles from *Discover* and 1.32 per 1000 words in the articles from *National Geographic*). It is logical to assume that the use of such similes enables the authors of PSAs to make the language of their narration closer to the readers' everyday speech or writing. In the article familiarizing the readers with some ocean and marine species which have been discovered not long ago and which are not so easy to detect, Gallo

(1993) mentions some type of algae which have not been studied well yet: "Dinoflagellates can look *like anything from damn dimpled pollen grains to hell's minuscule ship anchors*" (para. 7). In this sentence, the author uses two colloquial lexical items at the same time ("damn" and "hell's"). Their presence in the simile "like anything from damn dimpled pollen grains to hell's minuscule ship anchors" helps the author make the text of the article readable and attractive for non-specialist audiences.

Occasionally the similes performing the informative function in the text of PSAs may also contain some scientific terms or acronyms which should be pretty familiar to the general public. This tendency was observed in the articles from both subcorpora investigated in this project; in both cases, the normalized frequency of the similes having a popular scientific term or, in a few cases, an acronym in their lexical structure was rather similar (1.20 per 1000 words in the articles published in *Discover* and 1.08 per 1000 words in the articles from *National Geographic*). In the article about different species of deep-sea microbes published in *Discover*, Kunzig (2004) tells the readers about the research of a geologist investigating different components of the seafloor where numerous underwater bacteria come from, including numerous seashells and sea starts: "He knocked one over, felling it *as if it were a poplar tree to reveal its cross section*. Under a black outer layer there was a thick layer of pink and a core that was harder and greenish gray" (para. 4). In this example, the author uses the simile containing a well-known scientific term ("poplar tree"). Since the readers should be already familiar with this term before they start reading the article, the author does not provide any explanations of this term in the text of the article. At the same time, this example suggests that including in similes popular scientific terms helps the authors of PSAs make their descriptions and comparisons accessible to the general public.

In a few articles from *National Geographic* and *Discover* analyzed in this study, it was also possible to reveal the instances of similes containing acronyms. For instance, in the article "New Diseases, Toxins Harming Marine Life" from *National Geographic*, Dell'Amore (2013) resorts to simile in the introductory part of the article when developing the initial conventional metaphor "a bouquet of hot metal, diesel fumes, and barbeque." The use of simile after introducing this metaphorical expression lets him provide some additional explanation of the idea which he tries to express with the help of this metaphor: "*The final frontier smells a lot like a NASCAR race*. The source? Dying coral reefs" (para 8). Comparing the smell of some highly polluted areas of the Pacific Ocean with that of NASCAR should make it easier for the readers to infer the meanings conveyed by the metaphor "a bouquet of hot metal, diesel fumes, and barbeque". Thus, it is possible to say that in this case, the simile "the final frontier smells a lot like a NASCAR race" mainly performs the informative function, as it conveys the elements of some factual information directly connected with the topic of the article (that is, the negative consequences of polluting certain areas of the Pacific Ocean and the influence of those consequences on its inhabitants). At the same time, as the author of this article does not explain the acronym "NASCAR" (i. e., "National Association for Stock Car Auto Racing") which is used in the simile cited above, it is logical to assume that the use of this simile in the context of this article which is intended for non-specialist audiences may prove effective only in those cases when the readers are already familiar with the meaning of this acronym. Otherwise this simile will lose its explanatory potential, as in this case the reader will not know what the smells discussed in the article are actually compared to.

Analysis of the Similes Performing the Evaluative Function in the Text of the PSAs Published in *National Geographic* and *Discover*

The results of the analysis show that in the text of PSAs, simile may also serve the evaluative function. Let us illustrate this point using the examples from Lee's (2013) article reporting on some new research connected with different kinds of signals which humpback whales normally use for their communication with one another. At the very beginning of this article, the author characterizes the phenomenon of whales' signals as something really mysterious and incomprehensible: "It's *a mystery as old as civilization and as inscrutable as the mighty Sphinx*: why does a whale whistle?" (para. 1). The presence of the adjectives "old" and "inscrutable" in the simile used in this fragment of the article ("a mystery as old as civilization and as inscrutable as the mighty Sphinx") as well as the elements of exaggeration which can be traced in the phrases "as old as civilization" and "as inscrutable as the mighty Sphinx" enable the reader to understand the author's evaluation of the phenomenon discussed in the article. At the same time, the use of the word "mystery" in combination with the question "why does a whale whistle?" should help the author intrigue the readers, attract their attention to the subject of this article and maintain the readers' interest in the questions discussed in the article throughout its different parts and fragments while sharing his personal opinions and evaluations. Therefore, we can conclude that this simile mainly performs the evaluative function in the text of the article.

As well as in the case of the similes performing the informative function in the text of PSAs, calculating the normalized frequency of the similes used in their evaluative function revealed some quantitative differences in the use of this stylistic device in the corpus constructed for this project. All forms of the lexical structure of the similes performing the evaluative function and their normalized frequencies in the corpus of the study are presented in Table 4.

Table 4.

Normalized Frequencies of Using the Similes with Different Lexical Structure, Performing the Evaluative Function in the Text of PSAs

A characteristic element of the lexical structure of similes	PSAs from *National Geographic*	PSAs from *Discover*	Examples
Evaluative adjectives (without the use of lexical intensifiers and mitigating devices)	6.04	5.22	"The structure of reserve is quite logical and transparent. *It's plain as a pig on a sofa*." (Howard, 2015)
Lexical intensifiers and evaluative adjectives	4.58	2.16	"The tumor on the sick whale's back was *as frightening as flies on a dog's back*." (Netting, 2006)
Mitigating particle "not" and evaluative adjectives	1.09	1.17	"The glance of the adult dolphin was *not so tense as that of his newly-born child*." (Bittel, 2016)

A characteristic element of the lexical structure of similes	PSAs from *National Geographic*	PSAs from *Discover*	Examples
Word repetitions	–	0.98	"Its victim was scratched up *as if it were a <u>blind-blind</u> berry picker*." (Berglund, 2014)
Elements of exaggeration	0.94	–	"A five-year age gap between these two dolphins was *like a garden that needed <u>constant</u> attention*." (Foer, 2015)
Total	12.65	9.53	

As can be seen from Table 4, it appears that the articles published in *National Geographic* are characterized by a more frequent use of the similes conveying the elements of evaluative information, compared to the articles from *Discover* (12.65 per 1000 words in the articles from *National Geographic* vs. 9.53 per 1000 words in the articles published in *Discover*). This tendency can be connected with the fact that the authors of the articles from *National Geographic* tend to include in their narration more stories, opinions and personal impressions; these more "personal" elements of the content of their articles typically convey the authors' emotions and evaluations of the things described in those articles.

The lexical structure of the similes performing the evaluative function in the PSAs from the magazines analyzed in the study as well as the number of the similes with different kinds of lexical structure were different in this case too. The results of the analysis show that in some situations, the use of simile enables the authors of PSAs to share with the readers their attitude or evaluation of the topics discussed in their articles. This effect is achieved in the articles from both magazines investigated in this project, first of all, with the help of evaluative adjectives. The similes containing one or more evaluative adjectives tend to prevail in the articles from *National Geographic*, where the normalized frequency of their use is 6.04 per 1000 words (not including the similes with lexical intensifiers and the mitigating particle "not," which are discussed below). Nevertheless, in the articles from *Discover*, the similes containing one or more evaluative adjectives are the most popular kind of metaphorical comparisons conveying the author's evaluations. In these articles, the normalized frequency of using such similes is 5.22 per 1000 words (not including the similes with lexical intensifiers and the mitigating particle "not" either). This difference in the frequency of using similes in the text of PSAs is probably connected with the fact that, since the articles published in *National Geographic* are mainly intended for the readers who initially may not be interested in reading the materials about science, their authors have to make their content even more dynamic and thus even more attractive for the lay reader. Nevertheless, in both cases, the use of the similes containing evaluative adjectives enables the author to convey the necessary factual and especially emotional/evaluative information in an illustrative and expressive way. For example, in his article explaining to the readers why watching sea urchins seems to defy our knowledge of chemistry and physics, Rabinovich (2005) mentions that the sea urchin's methods of regenerating the spines that have broken off remind one of the process of making glass underwater: "You're dealing here with something *like a sophisticated*

piece of ceramics organized into extraordinary shapes" (para. 5). As can be seen from this example, while describing the sea urchin's methods of generating new spines, the author also shows his evaluation of this process with the help of the adjectives "sophisticated" and "extraordinary." Illustrating the phenomenon discussed in the article with the help of this simile enables the author to make his narration vivid and dynamic while creating in the readers' mind some new ideas, thoughts, and associations connected with this particular feature of sea urchins.

In some cases, the authors of PSAs enhance their evaluations expressed with the help of similes via the use of different lexical intensifiers (e. g. the adverbs "very," "really," "too," "all," "much more," "quite," "extremely," "overly," "largely," etc.). The similes whose lexical structure includes lexical intensifiers were revealed in both subcorpora analyzed in this project; however, the frequency of their use is much higher in the articles from *National Geographic* (4.58 per 1000 words), compared to those from *Discover* (2.16 per 1000 words). This observation corresponds with the above-mentioned tendency connected with a more frequent use of the similes with evaluative adjectives in the articles published in *National Geographic* and is probably connected with their authors' wish to convey the necessary scientific content in a lively and dynamic way. For example, in the final part of her discussion of the phenomenon of fluorescence and of some possible ways of its imitation with the help of man-made devices, Drake (2016) expresses her opinion about the idea of constructing fluorescent biospheres: "The concept of fluorescent biospheres is obviously speculative, as all hypotheses about alien life are. But it might not be so far-fetched. And there really would be nothing *quite as great as finding glowy aliens on the exoplanet nearest Earth*" (para. 14). In this part of the article, the author introduces the simile containing the evaluative adjective "great" whose meaning is enhanced with the help of the adverb "quite" appearing before this adjective. In the context of the fragment cited above, including the

lexical intensifier "quite" in the simile "quite as great as finding glowy aliens on the exoplanet nearest Earth" points to the author's personal position towards construction of man-made fluorescent biospheres, according to which the idea of creating such biospheres in the future sounds promising and exciting, even if at present it is still unlikely to be real.

It is interesting that although in most cases, the similes identified in the PSAs investigated in this project contain lexical intensifiers rather than hedges or any other mitigating devices, some of those similes include an evaluative adjective preceded by the negative particle "not." The normalized frequency of using such similes was quite similar in both subcorpora, although it was a little bit higher in the articles from *Discover* (1.17 per 1000 words) than in the articles published in *National Geographic* (1.09 per 1000 words). This slight difference in the number of such similes introduced into the articles from these two magazines may be associated with the tendency to use a little bit less emotional language in the articles from *Discover* which tend to include more factual information compared to those from *National Geographic*. Nevertheless, in both cases, the use of the negative particle "not" preceding an evaluative adjective makes the author's evaluations a bit more hedged and hence a bit less persuasive. For instance, in her article describing different forms of life in Mexico's underwater caves, Berglund (2014) describes some chemical reaction taking place in the cave system: "Iliffe and Pohlman thought a chemical reaction must be happening somewhere in the cave system – *not as dramatic as the billowing black clouds of dissolved minerals that erupt from deep-ocean hydrothermal vents*, but something more subtle" (para. 6). In this fragment of the article, the author refers to the chemical reaction taking place in the cave system as "not as dramatic as the billowing black clouds of dissolved minerals that erupt from deep-ocean hydrothermal vents." Including in the author's narration the simile containing the adjective "dramatic" combined with the use of the negative particle "not" allows the author to

convey her point of view about the degree of visibility of that reaction, compared to another kind of chemical reactions observed in underwater caves, in a hedged and mitigated way. It is also possible to assume that the presence of this simile in the text of the article encourages the readers to continue reading the next parts of the article, since it is only in this case that they will be able to understand why that chemical reaction is less "dramatic" than other kinds of chemical reactions taking place in underwater caves and why, in spite of this, this particular kind of chemical reaction still needs to be discussed in more detail in the text of the article.

This probably also explains why the similes containing the particle "not" combined with an evaluative adjective tend to be used at the beginning of the articles published in *National Geographic*. In the introductory part of the article "Blue Herons, Jellyfish, and Other Animals with Daily Commutes," Langley (2017) expresses her point of view about people's usual perceptions related to the size of the Universe: "Most casual observers would assume that the Universe is a space that expands into infinity, but *the answer is not as simple as gazing into a starry sky and hazarding a measurement*" (para. 2). Introducing the simile into this part of the article helps the author express and emphasize her position, according to which the traditional opinion about the Universe as a space expanding into infinity needs to be proved scientifically, but not to be based only on some popular stereotypes and outdated ideas about its size. At the same time, using this simile in the introductory part of the article makes the reader wonder what other, better explanation of the fact that universe is infinite can be given and what part of the Universe is actually occupied by oceans and seas. It is logical to assume that in such cases, the presence of similes should probably encourage the readers of PSAs to continue reading the next parts of the article, as only in this case they will be able to find the necessary information which they may be interested in.

In some cases, the use of simile enables the authors of PSAs to share with the reader his/her attitude or evaluation of the things discussed in his/her article in a more expressive and trustworthy way. In such cases, simile primarily serves the evaluative function. For example, in the introductory part of the article "What Is the Shape of the Universe?" mentioned earlier, the author expresses his point of view about people's usual perceptions related to the size of the universe: "Most casual observers would assume that the cosmos is a space that expands into infinity, but *the answer is not as simple as gazing into a starry sky and hazarding a measurement*". Introducing the simile into this part of the article helps the author express and emphasize his position, according to which the traditional opinion about the cosmos as a space expanding into infinity needs to be proved scientifically, but not to be based only on some popular stereotypes and outdated ideas about the size of space. At the same time, using this simile in the introductory part of the article makes the reader wonder what other, better explanation of the fact that universe is infinite can be given. In such cases, the presence of simile encourages the reader to continue reading the next parts of the article, as only in this case he/she will be able to find the necessary information which he/she may be interested in.

Along with the similes containing evaluative adjectives or both evaluative adjectives and lexical intensifiers or the mitigating particle "not," some of the similes which were identified in the corpus employed in this study help the readers reveal the author's evaluations and positions towards the things described in his/her article with the aid of some other devices as well. In particular, as the results of the analysis show, occasionally the authors of PSAs may resort to word repetitions when using similes. The similes whose lexical structure includes word repetitions were found only in the articles from *Discover*, where the normalized frequency of their use is 0.98 per 1000 words. In those cases when such similes are introduced into the author's narration, the latter

begins to sound even more emotional and persuasive, for example: "The arm inched up past my wrist to my shoulder, its suckers momentarily attaching and releasing *like cold kisses, or sometimes even freezing kisses*" (para. 4). This fragment of Tsar & Scigliano's (2003) article presents some elements of the authors' story about their experience of communication with an octopus from Seattle Aquarium. Repeating the word "kisses" which is used both times together with an adjective associated with something cold and hence not very nice ("cold" and "freezing") lets the authors of the article reveal their voice while describing their actual physical feelings associated with their interaction with that octopus.

While the similes with word repetitions were not revealed in the PSAs published in *National Geographic*, it was found that, unlike the articles from *Discover*, some of the articles from *National Geographic* appear to include the examples of the similes conveying the elements of exaggeration. The normalized frequency of their use in the PSAs from *National Geographic* is 0.94 per 1000 words. Introducing these similes into their narration helps the authors of those articles emphasize the necessary emotional and evaluative information. As the similes including the elements of exaggeration mostly occur in the narratives about some episodes from the author's and/or scientists' travel and research experience, they are often used for drawing the readers' attention to some important facts or features of the objects or phenomena presented in those narratives. For instance, in her story about her visit to the world's largest single marine reserve created in the South Pacific, Howard (2015) describes scientists' research activities aimed at investigating the marine fauna of that reserve: "Sala's dive team could see for 250 feet (75 meters) and spied many sharks and a vast garden of pale blue coral that looked *like giant roses*" (para. 3). In this sentence, Howard shows her surprise about the size of those reefs with the help of the simile "like giant roses" conveying the elements of exaggeration. Using the adjective "giant" instead of

a more stylistically neutral adjective (e. g. “huge,” “enormous,” “big,” “high,” etc.) makes the reader pay more attention to some emotional and evaluative implications following from the author’s descriptions incorporated into this narrative from the initial part of her article. Besides, as can be seen from the example cited above, introducing the similes containing the elements of exaggeration into the text of PSAs enables their authors to convey the necessary factual and emotional/evaluative information in a lively and expressive way.

Discussion and Conclusions

The main purpose of the project presented in this chapter was to investigate the use of the similes introduced into the text of PSAs for conveying the necessary factual and emotional/evaluative information. As mentioned earlier, the importance of investigating the use of this and other devices widely used in PSAs is connected with the lack of research providing a systematic description of particular linguistic and pragmatic features typical of concrete genres of popular science texts, including the PSAs dedicated to different subjects and published in different sources. As similes are often introduced into PSAs for making their texts interesting and accessible to non-specialist audiences, analyzing their use in this particular genre should help us achieve a better understanding of various linguistic techniques and devices which enable writers to convey the necessary scientific content in a clear and engaging way. At the same time, as shown, for example, by Aasheim (2012) and Hussein and Sawalha (2016), the use of corpora allows researchers to reveal and examine different quantitative and qualitative variations in the structure of similes and in the functions which they perform in certain varieties of one and the same genre. In this project, the use of corpora and corpus tools allowed me to identify the

differences and similarities in the use of similes in the PSAs published in two particular magazines (namely, *National Geographic* and *Discover*).

It follows from the results of this analysis that the use of similes in the text of the PSAs included in the two subcorpora investigated within this study are characterized by some common and varying features. For example, in both cases, the authors of those articles tend to resort to similes for conveying the necessary factual and evaluative/emotional information in a lively and expressive way. Thus, it is possible to say that in both cases, the similes revealed in the corpus constructed for this project may perform the informative (cognitive) and evaluative functions. However, as shown in Tables 3 and 4, the lexical structure of those similes and the frequency of using the similes with a different lexical structure could be different in both cases, depending on the authors' purposes, the assumed target audience, and some other contextual factors. As indicated in Table 3, while the similes which are mostly aimed at conveying the necessary factual information prevail in the articles from *Discover*, the articles from *National Geographic* are characterized by a more frequent use of the similes which contain the elements of evaluative or emotional information. Besides, among those similes which help writers make the necessary scientific content clear and accessible to the general public, the similes containing stylistically neutral adjectives denoting individual features of an object or phenomenon described in the article prevail in the PSAs from *Discover*. The similes containing well-known scientific terms or acronyms and especially the similes consisting of only stylistically neutral nouns (with or without articles) are also used more often in the articles published in *Discover.* These tendencies are probably connected with the fact that these articles are intended, first of all, for the readers who should be already familiar with certain areas of science (and with science in general) by the time they start reading the magazine. They are also more likely to be motivated to explore the

subject of the article in more detail after they finish reading it. On the contrary, unlike the articles from *Discover*, the texts of some of the articles from *National Geographic* include the similes containing the synonyms of the scientific terms introduced into the text of those articles. Besides, the presence of colloquial words in the lexical structure of similes occurs in these articles a little bit more often too. The main reason for the differences observed in the range and frequencies of using similes with these features of lexical structure is probably connected with the fact that, since the articles published in *National Geographic* are addressed to different categories of readers (including those who may be not interested in the questions of science before they become familiar with the content of those articles), their authors need to use different linguistic, stylistic and rhetorical devices which would help them make the content of their articles interesting and engaging for the general public.

As shown in Table 4, some qualitative and quantitative differences were also observed in the use of the similes which mainly perform the evaluative function in the articles analyzed in this study. In particular, unlike the similes which serve the informative function in the text of PSAs, the similes which mainly perform the evaluative function in PSAs, prevail in the articles published in *National Geographic*. In particular, these articles are characterized by a more frequent use of the similes including evaluative adjectives and lexical intensifiers, compared to the articles from *Discover*. At the same time, the results of the analysis suggest that the authors of the articles from *National Geographic* and especially from *Discover* tend to mitigate their evaluations with the help of using evaluative adjectives preceded by the particle "not." When the authors of the PSAs published in *Discover* still need to emphasize their position towards the things described in the articles, occasionally they may resort to the similes containing word repetitions. Although the similes with word repetitions were not revealed in the articles from

National Geographic, the results of the analysis show that, in some cases, the authors of the articles from this magazine use the similes containing the elements of exaggeration. This probably helps their authors draw the readers' attention to the necessary elements of their narration and to make it vivid and expressive. The prevalent use of the similes containing the elements of evaluation and persuasion in the PSAs from *National Geographic*, on the one hand, allows their authors to make their narration accessible to non-specialist audiences and, on the other hand, enables them to persuade the readers that the questions discussed within those articles are really interesting and important.

The results of the analysis point to the fact that introducing into the text of the PSAs investigated in this study the similes with the lexical structure containing the elements of evaluative or emotional information allows their authors to convey the necessary scientific content in a dynamic and engaging way. These observations coincide with the findings of Hyland's study (2010) which suggest that proximity between the authors and readers of PSAs is achieved with the help of introducing evaluative lexical units, hedges, metaphorical expressions, rhetorical questions, and some other structural and linguistic means making research accessible to non-specialists and allowing them to recover the voice of the scientist. At the same time, as demonstrated in some previous related studies (e. g. Hempel & Degand, 2008; Myers, 2003; Rowan, 1989), the use of clichés, phraseological units, colloquial and evaluative vocabulary as well as different stylistic devices in the text of PSAs allows writers to make their narration vivid, persuasive and engaging to non-specialist audiences. This probably also refers to the similes whose lexical structure, as shown earlier, may contain some of these linguistic means (e. g. evaluative vocabulary, colloquial words, lexical intensifiers, hedges, etc.) as well. The use of the similes whose lexical structure includes these and the other linguistic devices described above

suggests the existence of close connections between the factual and emotional-evaluative information conveyed in the text of PSAs about ocean life research.

The differences revealed in terms of the frequency and the lexical structure of the similes introduced into the two varieties of the articles included in the corpus of the study show that the source of publication needs to be regarded as one of the major factors affecting the use of this stylistic device in the texts of PSAs. However, in spite of some variations observed in the lexical structure and the frequency of using similes in the PSAs from *Discover* and *National Geographic*, the use of simile in both of these varieties is characterized by some invariant features as well. The existence of these invariant parameters lets us make sure that, despite some differences in the ways of using similes, observed in the articles from different magazines, all these texts belong to the genre of PSA. For example, in many cases, the authors of PSAs resort to similes for explaining new scientific terms which they introduce into their narration before using similes. This way they help the readers make some logical connections between the necessary scientific content and the objects and phenomena which were familiar to the readers before they start reading the article. This observation goes well with the findings reported in Moder (2008), according to which, in most cases, similes are exploited for establishing and drawing the listeners' or readers' attention to the mappings which were not extended in that discourse before. This also corresponds with the findings of Parkinson and Adendorff's study (2004) which suggest that providing meanings of scientific terms and making connections between different notions and concepts allow the authors of PSAs to present scientific content in the terms of the commonplace and unexceptional. In addition, as noted by Goncharova and Shishkina (2005), providing the explicit connections between different terms and concepts which are mentioned in

popular science texts enables their authors to convey the necessary scientific information in an accessible and precise way.

At the same time, based on the results of the present study, it is possible to assume that introducing similes into the text of the PSAs from *National Geographic* and *Discover* (especially into their introductory part) may be aimed at achieving some other communicative and pragmatic purposes as well. For example, in some cases, the authors of the PSAs analyzed in this project also resort to simile attempting to convey some factual information related to the subject of their articles in an illustrative and accessible way. In some other situations, the authors of the articles investigated in this study employ similes for sharing with the readers and emphasizing their own point of view about the questions discussed in their articles. In this connection, we can conclude that in both varieties of PSAs, the similes with different kinds of lexical structure serve the informative (cognitive) and evaluative functions. This multi-functionality of simile determines the complex, dynamic and changing nature of the language mapping of the world reflected in the text of these varieties of PSAs dedicated to ocean life research.

While this study was aimed at investigating the use of similes in the PSAs dedicated to the same subject (ocean life research) but published in two different magazines, in the future related studies, it could be possible to continue examining the lexical structure and some other features of simile (e. g. their grammatical structure, the communicative and pragmatic purposes of using them in printed and online PSAs, etc.) using PSAs about ocean life research or some other topic, which would be published in some different magazines (e. g. *Scientific American*, *Popular Science*, etc.) or on different Web-sites. This would enable researchers to obtain more data about the influence of the specific characteristics of a particular magazine on the use of simile in the text of PSAs dedicated to the same subject. At the same time, investigating the use

of simile in the articles published in the same magazine but dedicated to two different subjects would allow researchers to reveal some possible correlations between the subject of the article and certain trends connected with the use of simile for conveying the necessary factual and evaluative information. Various linguistic features of similes employed in the text of PSAs and/or their pragmatic and communicative functions could be further investigated with the help of using questionnaires and interviews with the authors and/or readers of those articles. Increasing the corpus of PSAs investigated in such studies would also be helpful for arriving at a better understanding of some specific ways of using similes in this kind of science popularization, compared to other popular science texts.

CHAPTER IV

ON THE USE OF NARRATIVES ABOUT SCIENTISTS' TRAVEL AND/OR RESEARCH EXPERIENCE IN THE TEXT OF POPULAR SCIENCE ARTICLES

Introduction

The studies described in Chapters 2 and 3 were aimed at investigating the use of individual linguistic or stylistic devices (namely, theory-constitutive metaphors and similes) in the text of certain varieties of PSAs dedicated to different subjects or taken from different magazines, respectively. At the same time, in some cases, along with some other linguistic and stylistic means (e. g. scientific terms, proper names, evaluative lexical units, idioms, etc.), the metaphorical expressions and similes introduced into the text of PSAs can be used for conveying the necessary factual and evaluative information in different types of narrative (Dahlstrom, 2014; Gastel, 1983). It was shown in some previous studies that narratives appear to be one of the most effective ways to achieve a greater degree of personalization, contingency and humor in popular science texts, including the texts published in popular science magazines (e. g. Avraamidou & Osborne, 2009; Badenschier & Wormer, 2012; Norris et al., 2005). According to Dahlstrom (2014), narratives can be regarded as a communication format which follows a particular structure that describes the cause-and-effect relationships between the events that take place over a particular time period and that impact particular characters.

Based on this definition, it is possible to conclude that causality, temporality, and character are the inherent components of a narrative. Besides, as shown by Avraamidou and Osborne (2009), narratives should include the following components: events, time, a narrator and agency (that is, the actors who cause and experience events).

At the same time, according to Graesser, Olde and Klettke (2002), the situations and episodes in narrative have a close correspondence to everyday experiences; so the comprehension mechanisms are much more natural than those recruited during the comprehension of other discourse genres such as argumentation, expository text, and logical reasoning. In addition, narratives are often associated with increased recall, ease of comprehension, and shorter reading times (Schank & Abelson, 1995; Zabrucky & Moore, 1999). These benefits may not come from simplicity, as coherent narratives demand a high level of complexity in both internal complexity and alignment to cultural and social expectancies (Bruner, 1991; Monteagudo-Gonsalez, 2011). Instead, narratives seem to offer intrinsic benefits in each of the main steps of processing information: motivation and interest, allocating cognitive resources, elaboration, and transfer into long-term memory (Glaser, Garsoffky, & Schwan, 2009). This corresponds with the findings suggesting that narratives are easier to comprehend and that readers typically find them more engaging than traditional logical-scientific communication (e. g. Bruner, 1986; Green, 2006).

Although storytelling often has negative connotations with science (e. g. Katz, 2013), interest in narrative within the field of scientific and technical communication has lately been growing (Ballentine, 2010; Carroll, 2010; Ittersum, 2014). Several researchers (e. g. B. Barton & M. Barton, 1988; Blyler, 1996; Dahlstrom, 2014; Rentz, 1992) argued against a devaluation of narrative in scientific or technical communication and business writing. Including the elements

of storytelling in the author's narration becomes especially important in those cases when the context moves from data collection to the communication of science to non-expert audiences. As a rule, non-experts get most of scientific information from mass media content, including popular science magazines. Since media practitioners have to compete for the attention of their audiences, they often rely on stories, anecdotes and other narrative formats to cut through the information clutter and resonate with their audiences (Dahlstrom, 2014).

At the same time, it has been shown in research literature that science can appear in various types of narratives, including news stories and feature stories, editorials, investigative reports, columns of various types, interpretive stories (for example, analyses of trends), or background stories (Gastel, 1983). According to some scholars, the use of stories portraying the process of science is more likely to attract the readers' attention to the topic of the article (Austin, 2005; Gastel, 1983; Montgomery, 2003; Ness, 2007). In addition, the narratives containing biographical or autobiographical elements appear to be an essential element of public engagement in different areas of science (Moezzi, Janda, & Rotmann, 2017; Stewart & Nield, 2013). This shows the importance of investigating such narratives in popular science texts delivered to non-specialist audiences via mass media, including the texts of PSAs.

The study presented in this chapter was aimed at investigating the use of the narratives about the travel and/or research experience of scientists(s) involved in the studies described in PSAs. It addresses the following research questions:

1. What are the communicative and pragmatic purposes of using the narratives about scientists' travel and/or research experience in the text of PSAs published in two different popular science magazines (namely, *National Geographic* and *Discover*)?

2. What linguistic means used in narratives help the authors of PSAs achieve their pragmatic and communicative purposes?

Thus, the main purpose of the study discussed in this chapter was to analyze the use of the narratives about scientists' travel and/or research experience in the texts of PSAs which typically serve as a specific medium aimed at conveying the necessary scientific content to the lay audience. The analysis of PSAs from different sources should help us arrive at a better understanding of various contextual factors that may influence the use of this type of narratives and their language in this kind of popular science writing. Besides, similar to the study of simile described in Chapter 3, comparing the texts of the articles published in two different magazines intended for different categories of non-specialist audiences should let us understand whether specific characteristics and requirements of a particular magazine have some influence on the ways of using narratives in the text of a concrete PSA.

Research Design

Identification of the narratives about scientists' travel and/or research experience in the text of PSAs was based on the content analysis of the articles included in the corpus of the study. It means that in this study, the narratives about scientists' travel and/or research experience were identified based on the content of the articles under investigation. In accordance with the above-mentioned criteria suggested by Avraamidou and Osborne (2009), all narratives analyzed in this study included the following components: events (in this case, certain actions connected with the reseacher's travel/research experience), time, a narrator (that is, the author of the article), and agency (i. e. the researcher(s) involved in the study described in the article).

In line with Franzosi (2010), in this study, the communicative and pragmatic purposes of the narratives about scientists' travel and/or research experience were identified by inferencing from the context of the PSAs where they were actually used. For example, based on his investigation of the content of the narratives introduced into the popular science texts about social sciences, Franzosi (2010) concludes that in science popularizations, their authors tend to use narratives for providing the necessary scientific and/or additional (e. g. evaluative or emotional) information when:

- presenting background information;
- highlighting overall research outcome;
- reviewing related research;
- presenting new research;
- indicating consistent observations;
- describing data collection procedure;
- describing experimental procedure;
- explaining research outcome;
- stating research conclusions.

Based on the content analysis of the PSAs investigated in this part of the dissertation project, the model presented above was specified and modified for the purposes of this study. This new, modified classification includes the following communicative and pragmatic purposes which can be performed by scientists' narratives used in the PSAs from *National Geographic* and/or *Discover*:

- providing information about the context and settings of the research presented in the article;

- familiarizing the readers with the most important aspects of the research described in the article;
- providing the necessary factual or evaluative information about data collection procedures to non-specialist audiences;
- providing the necessary factual or evaluative information about experimental procedures to non-specialist audiences;
- providing information about the major results and potential outcomes of one's research;
- conveying the researcher's and/or the author's evaluations of the subject of the article;
- conveying the researcher's and the author's hypotheses and assumptions based on their observations related to the subject of the article;
- expressing the author's attitude to the observations and interpretations suggested by scientists;
- familiarizing the readers with the author's and/or researcher's views on the possible contributions of the study to the field;
- making the author's narration personalized, persuasive and authentic; and
- making the necessary content vivid and engaging.

The evidence presented in this paper was collected from 32 PSAs about ocean life (see the References), – as, according to several researchers (e. g. Macnamara, 2005; Potter & Levine-Donnerstein, 1999; Trilling & Jonkman, 2018; Weber, 1990), the sample consisting of at least 30 texts typical for the genre to be investigated and having approximately the same length is needed for conducting an adequate content analysis of the texts published in mass media (including the

texts from popular science magazines). As well as in the research described in the previous two chapters, all articles investigated in this study were written either by science journalists or, in some cases, by the experts in the fields related to the subject of the articles; each of them includes at least one narrative about scientists' travel and/or research experience (in most cases, scientists' narratives introduced into the PSAs analyzed in this study include some information about both their travel and research experience at the same time). Similar to the research into the use of simile in the text of PSAs discussed above (see the Research Design section of Chapter 3), originally, the articles analyzed in this project were taken from different issues of the US printed magazines *National Geographic* (the first 16 articles analyzed in this study; 19,162 words in total) and *Discover* (the other 16 articles investigated in this study; 19,124 words in total) published between 1998-2016. All of them are aimed at familiarizing the readers with the research into the biological features of certain organisms inhabiting seas and/or oceans. Using this research material for the purposes of this study should help us understand whether the target audience of the articles published in different magazines and some other contextual factors (including the requirements of the source where this or that text is published, communicative and pragmatic purposes of the author of a concrete text, the topic of a certain article, etc.) determine the use of the narratives about scientists' travel and/or research experience in the text of PSAs.

Data Analysis and Findings

Common Features of Using the Narratives about Scientists' Travel and/or Research Experience in the PSAs Published in *National Geographic* and *Discover*

Evidence from the articles published in both magazines suggests that the use of the narratives about scientists' travel and/or research experience in both magazines is characterized by some common features which are summarized in Table 5 presented below.

Table 5.

Common Features of Using the Narratives about Scientists' Travel and/or Research Experience in the Popular Science Articles Published in National Geographic and Discover

Communicative and pragmatic purposes	Linguistic means
• providing information about the context and settings of the research presented in the article	• proper names • numbers • well-known scientific terms • prepositional phrases
• familiarizing the readers with the most important aspects of the research described in the article	• proper names • well-known scientific terms
• making the author's narration personalized, persuasive and authentic	• direct quotations • metaphorical expressions

Communicative and pragmatic purposes	Linguistic means
• conveying the researcher's and/or the author's evaluations of the subject of the article	• evaluative lexical units • metaphorical expressions • idioms
• making the necessary content vivid and engaging	• metaphorical expressions • comparison constructions

The results of this analysis suggest that in both magazines analyzed in this study, the narratives about scientists' travel and/or research experience can be used for different pragmatic and communicative purposes. In some cases, this type of narrative is introduced into the text of PSAs for presenting the necessary background information in an engaging and entertaining form. For instance, in the article "Splendor in the Dark" from *Discover*, the use of this kind of narrative allows the author to introduce the researcher and to show the context in which the scientific observations discussed in the article were actually done:

Excerpt #1 (McClintock, 2004)

In 1984[7], encased in a huge yellow metal diving suit equipped with foot-controlled thrusters, deep-sea biologist Edith Widder sank into the Pacific Ocean on her first deep dive. With her suit's lights turned on, she watched shrimp, fish, and jellyfish rising past a clear, bubble-like dome that covered her head. Beyond the reach of the artificial lights, the sea was pitch black. Then at 800 feet, she switched them off.

[7] In this and all other excerpts from PSAs cited in this chapter, the examples of the linguistic means introduced into scientists' narratives about their travel/research experience have been underlined by me.

As her eyes adjusted, she says, "little dots like fairy dust, splats like puffs of liquid, sparks like embers thrown up from a campfire" emerged from the dark. "Except all these lights were blue. It was absolutely mesmerizing, and I couldn't believe how much there was. It was everywhere!" (para. 2-3)

The fragment of the article presented in Excerpt 1 can be considered a narrative about scientists' travel and/or research experience: as well as all other narratives analyzed in this paper, it has a narrator (the author of the article) and an agent (i. e. the researcher involved in the study discussed in the article). The narrative in Excerpt 1 describes the events which took place during the researcher's first deep dive, and it contains the necessary information about the time when these events were happening ("in 1984").

The necessary contextual information is conveyed in Excerpt 1 via the use of proper nouns ("Edith Widder" and "the Pacific Ocean"), numbers, well-known scientific terms ("thrusters," "shrimp," "fish," and "jellyfish"), and prepositional phrases ("in 1984," "with her suit's lights turned on," and "at 800 feet"). At the same time, the narrative presented in Excerpt 1 includes some linguistic means containing the elements of emotional or evaluative information, such as an evaluative lexical unit ("huge") and a metaphorical expression ("a clear, bubble-like dome that covered her head"). The use of the direct quotations at the end of this narrative enables the author to preserve the style of speech, expressivity, and terminology peculiar to the researcher (including the use of figurative language and an exclamation at the end of her utterance) while conveying the necessary factual and evaluative information related to the events described in the narrative.

As can be seen from Table 5, in several articles from National Geographic and Discover analyzed in this study, the stories narrating about scientists' travel and/or research experience are also used for familiarizing the readers with the most important aspects of the new research.

These aspects typically include the subject of research, the name(s) of the researcher(s), the purpose of research, and the actions which the scientist(s) undertook to be able to conduct that research. In these narratives, the authors of the articles share with the readers some information about the researchers' observations, initial thoughts and impressions related to the subject of their research. Including this information in the narratives helps the authors of the articles make research accessible to non-specialists and enables them to recover the voice of the scientists involved in the research. In the article "Looking for Life on Proxima B? Try Glowing Aliens" from *National Geographic*, the author tells the readers the story from the researchers' experience which can be considered the first stage of the research described in the article:

Excerpt #2 (Drake, 2016)

That's where O'Malley-James and Cornell University's Lisa Kaltenegger enter the story. The goal, Kaltenegger says, was to think a bit outside the box and come up with various strategies that might help life on these worlds survive…

"We decided to look into more advanced organisms and see if they had any mechanisms that could produce signs of life nobody thought of yet," Kaltenegger says…

Then she and O'Malley-James took a deep dive into the strange world of undersea life, where many creatures already sort of look like aliens … and that's when they came across corals. (para. 3-5)

Excerpt 2 includes a fragment of the narrative describing the events in which the researchers (O'Malley-James and Lisa Kaltenegger) were involved in the process of conducting the study described in the article. The author shows explicitly where the story starts ("That's where O'Malley-James and Cornell University's Lisa Kaltenegger enter the story") and how it is connected with the subject of the article – biofluorescence as sign of life in depths of sea and

oceans and in the cosmos ("and that's when they came across corals"). The narrative also introduces the purpose of the research presented in the article ("to come up with various strategies that might help life on these worlds survive") and enlists the actions undertaken by the researchers ("we decided to look into more advanced organisms," "Then she and O'Malley-James took a deep dive into the strange world of undersea life," "that's when they came across corals," etc.).

The necessary factual information is introduced into Excerpt 2 with the help of proper names ("O'Malley-James," "Cornell University," and "Lisa Kaltenegger") and well-known terms ("organisms" and "corals"). As well as in the previous case, the use of a direct quotation of the words of one of the researchers involved in that study ("We decided to look into more advanced organisms and see if they had any mechanisms that could produce signs of life nobody thought of yet," Kaltenegger says) adds authenticity to the author's narration, as it allows him to preserve the language and style of the researcher's speech. At the same time, as shown by Semino (2008), the use of metaphors and metaphorical comparisons in science popularizations allows their authors to introduce the necessary content in a vivid, humorous and engaging way. In addition, according to Knudsen (2003), the presence of metaphors in scientists' narratives allows the authors of science popularizations to explain the necessary scientific issues and hypotheses clearly and vividly as well as to entertain their readers with some humorous phrasings and ambiguities. In this connection, it is possible to say that combining the use of an idiom ("to think a bit outside the box"), a metaphorical expression ("signs of life"), and a comparison construction ("where many creatures already sort of look like aliens") within the narrative cited above lets the author of the article make the researchers' and his own explanations clear and accessible to the general public, as, according to Semino (2008). This

multifunctionality of the narratives introduced into PSAs determines the complex and changing nature of the conceptual mapping of the world reflected in this kind of text.

Specific Features of Using the Narratives about Scientists' Travel and/or Research Experience in the PSAs Published in *National Geographic*

The results of this analysis suggest that, along with the common features of using the narratives about scientists' travel and/or research experience in the articles from *National Geographic* and *Discover*, the use of this type of narratives in the articles from *National Geographic* is characterized by some other features as well. Table 6 outlines specific characteristics of the narratives about scientists' travel and/or research experience introduced into the PSAs published in *National Geographic*.

Table 6.

Specific Features of Using the Narratives about Scientists' Travel and/or Research Experience in the Popular Science Articles Published in National Geographic

Communicative and pragmatic purposes	Linguistic means
• providing information about the major results and potential outcomes of one's research	• proper names • popular terms • abbreviations • direct quotations
• expressing the author's attitude to the observations and interpretations suggested by scientists	• evaluative lexical units • lexical intensifiers • personification • metaphorical comparisons

Communicative and pragmatic purposes	Linguistic means
• conveying the researcher's and the author's hypotheses and assumptions based on their observations related to the subject of the article	• 1st person pronouns • modal verbs

As follows from Table 6, in the articles from *National Geographic*, *the* stories about the travel and/or research experience of the scientist(s) involved in the study are sometimes used for providing information about the major results and potential outcomes of one's research. The narratives used for this purpose tend to contain some information about the observations and results of the research described in the article which, in the author's opinion, would be of interest to the readers. In the example of such a narrative from the article "Warming Pacific Makes for Increasingly Weird Ocean Life" published in *National Geographic*, which is cited below, the author shares with the readers several episodes about his correspondence and communication with the researchers involved in the study, including this one:

Excerpt #3 (Cornwall, 2015)

Weeks after the trip, Reisenbichler e-mails me the results of the MRS experiment. "While we do see some evidence of elevated oxygen consumption rates in situ for two out of the three species sampled during the last deployment, the sample numbers are too low to jump to any conclusions," he says. Inconclusive but tantalizing, a suggestion that the jellies may indeed be doing more of everything down there. The best news of all may be word from Robison that the MRS equipment is performing "like a champ," promising harder data ahead.

Yet a grim feeling pervades the aquatic realm. Later in the spring, Widmer tells me, "we would expect the sea lions to be ripping the top and bottom fins off the molas and throwing them around like Frisbees, skipping them

on the surface. But they haven't been doing it this year or last year or the year before" – because the molas are gone. (para. 5-6)

The narrative in Excerpt 3 describes the main results of the researchers' experiment discussed in the article. It enlists several events ("… Reisenbichler e-mails me the results of the MRS experiment," "the MRS equipment is performing 'like a champ'…," "… a grim feeling pervades the aquatic realm," "later in the spring, Widmer tells me…," etc.) and shows the time when these events were happening ("weeks after the trip" and "later in the spring"). The necessary factual information about the major observations and results of the experiments described in the article is provided with the help of proper names ("Reisenbichler," "Widmer," and "Robison"), popular scientific terms ("jellies," "sea lines," "molas," "oxygen consumption rates," and "in situ"), and the abbreviation "MRS" ("the MRS experiment" and "the MRS equipment"). In this case, the direct quotations of the researchers' comments and hypotheses convey the necessary factual information about their experiment as well (e. g. "While we do see some evidence of elevated oxygen consumption rates in situ for two out of the three species sampled during the last deployment, the sample numbers are too low to jump to any conclusions" and "… we would expect the sea lions to be ripping the top and bottom fins off the molas and throwing them around like Frisbees, skipping them on the surface. But they haven't been doing it this year or last year or the year before").

It is interesting that in Excerpt 3, the agents' (that is, the scientists') remarks about their research experience are combined with the narrator's (that is, the author's) comments. The elements of the dialogue between the researcher and the author of the article which are cited throughout the whole episode point to the presence of certain shifts and contradictions in the author's narration. The simultaneous use of several evaluative lexical units some of which

acquire the opposite meaning in the context of the narrative ("best"-"grim," "inconclusive"-"tantalizing"), lexical intensifiers (e. g. "too, "all," and "indeed"), personification ("… a grim feeling pervades the aquatic realm"), and the metaphorical comparison "the MRS equipment is performing 'like a champ' " creates the effect of irony and thus also shows the author's skeptical attitude to some initial interpretations of the experiment which was described in the previous part of the article. At the same time, repetitions of the 1st person pronouns ("I" and "we") and the modal verb "may" throughout Excerpt # 3 signal the readers that the story presented in this part of the author's narration includes the researcher's and the author's hypotheses and assumptions which are based on their observations related to the subject of the article. This leads to forming in the readers' mind some new associations and ideas related to the topic of the article.

Specific Features of Using the Narratives about Scientists' Travel and/or Research Experience in the PSAs Published in *Discover*

It follows from the results of this analysis that the use of the narratives about scientists' travel and/or research experience in the PSAs published in *Discover* may be characterized by some features which are not typical of that in the articles from *National Geographic*. These features are summarized in Table 7 presented below.

Table 7.

Specific Features of Using the Narratives about Scientists' Travel and/or Research Experience in the Popular Science Articles Published in Discover

Communicative and pragmatic purposes	Linguistic means
• providing the factual information about data collection procedures to non-specialist audiences	• proper names • scientific terms and their brief explanations, definitions, or synonyms • numbers
• conveying the necessary evaluative information about data collection procedures to non-specialist audiences	• conventional metaphors • comparison constructions • exaggerations
• providing the factual information about experimental procedures to non-specialist audiences	• proper names • popular terms • numbers • expressions for rounding numbers • prepositional constructions
• conveying the necessary evaluative information about experimental procedures to non-specialist audiences	• evaluative lexical units • lexical intensifiers
• familiarizing the readers with the author's and/or researcher's views on the possible contributions of the study to the field	• direct quotations

As shown in Table 7, the authors of the articles from *Discover* tend to employ the narratives about scientists' travel and/or research experience when telling non-specialist readers about data collection procedures, including the processes of data identification, selection and delimitation. As a rule, the narratives used for this purpose include information about the procedure of doing the field work, observations or experiments involved in the research described in the article. For example, when describing the researchers' field work aimed at investigating some inhabitants of the Galapagós rift and when talking about the procedure of data collection involved in this work, the author of the article "Sweeping the Ocean Floor" from *Discover* provides a few facts and comments on the researchers' previous experience of collecting data for some similar research purposes:

Excerpt #4 (Kunzig, 2007)

Fred Grassle never forgot. He had been one of the first scientists to get a good look at the Galápagos hot springs. A biologist from Rutgers University in New Jersey specializing in polychaetes – tiny caterpillar-like things, also known as bristle worms – he found himself staring out Alvin's porthole at tube worms almost as tall as he was. He was as amazed as anyone, but he soon went back to the larger problem of studying all the rest of the ocean. In the 1980s, he and his colleague Nancy Maciolek of Battelle Ocean Sciences in Massachusetts used a simple device called a box corer to collect undisturbed square-foot samples of seafloor mud. Judging from how many new species they found each time they lowered their device 7,000 feet onto the continental slope off New Jersey, Grassle and Maciolek estimated that there were up to 10 million animal species living on the ocean floor. If so, the deep was as diverse as the tropical rain forest. (para. 6)

As can be inferred from this example, along with providing a brief description of the methods of data collection, such narratives usually contain some factual information about the researchers themselves, the time and process of data collection, the sources of data, and/or data

size. They also include some details about the researchers' thoughts, emotions, comments or remarks about the process of data collection and about the data which they analyzed in their studies. Thus, it is possible to say that, in some cases, the main purpose of the narratives about scientists' travel and/or research experience introduced into the articles from *Discover* is to provide the readers with the factual and evaluative information about the process of obtaining the data used in that kind of research which is presented in the article. Although the narratives used for this purpose tend to contain many scientific terms conveying the necessary factual and scientific information (e. g. "polychaetes," "bristle worms," "tube worms," and "box corer" in Excerpt #4), they are usually accompanied with the author's brief explanations, definitions and/or the synonyms which should be familiar and clear to the lay readers.

It can also be seen from the example provided above that the elements of factual information conveyed with the help of scientific terms, numbers ("1980s," "7,000 feet," and "10 million animal species") and proper names ("Fred Grassle," "the Galapagós hot springs," "New Jersey," "Alvin," "Nancy Maciolek," "Batelle Ocean Sciences," "Massachusetts," etc.) are combined in such narratives with certain linguistic and stylistic devices, which makes the text of the story emotional and vivid. In particular, the use of several comparison constructions ("tiny caterpillar-like things," "tube worms almost as tall as he was," and "the deep was as diverse as the tropical rain forest"), an instance of exaggeration ("the larger problem of studying all the rest of the ocean"), and conventional metaphorical expressions ("seafloor" and "the ocean floor") helps the intended readers of the article perceive and adequately understand the scientific information about the data collection procedure which is presented in it.

In some cases, the stories about scientists' travel and/or research experience are also used for describing the experimental procedures which are involved in the studies presented in the articles from *Discover*:

Excerpt #5 (Svitil, 1995)

John Heyning, the head of the museum's marine mammal program and one of the lab's two permanent staff members, has been recovering stranded marine mammals for nearly two decades. The dolphins, he says, are easy: adults usually weigh no more than 200 pounds, so most of the time it takes just one or two people to put the bodies into the back of a pickup truck. But sometimes the work is more grueling, and gruesome. In the early spring, Heyning spent a long day at Venice Beach recovering the remains of a humpback whale – a rarity as strandings go… The body was far too large to move – adult humpbacks can weigh up to 60 tons – so the recovery team decided to take just the head, which, pound for pound, would give them the most information about the animal's life… (para. 9)

Excerpt 5 contains a detailed description of the procedure involved in the process of recovering the remains of a humpback whale. As well as in the previous example, the use of proper names ("John Heyning" and "Venice Beach"), popular terms ("mammals," "dolphins," and "humpback whale") and numbers ("200 pounds" and "60 tons") allows the author of the article to convey the necessary factual information about the events associated with the researcher's experiment described in the article. Using prepositional constructions for indicating the time when the events described in the narrative were actually taking place ("in the early spring" and "after cutting through skin, blubber, and muscle with sickle-like Japanese flensing knives") *makes the text of the article logical and coherent*. At the same time, the presence of different expressions for rounding numbers ("nearly," "no more than," or "up to") should make it

easier for the readers to perceive and understand the data indicated in this narrative, including the information about the weight of dolphins and adult humpback whales.

Along with the factual information about the researcher's actions, this narrative also contains the researcher's and the author's evaluations of the things discussed in the article. These evaluations are conveyed via the use of the evaluative lexical units with the contrasting meaning ("easy," on the one hand, and "grueling" and "gruesome," on the other) and of lexical intensifiers ("more," "far too," "just," etc.). Deploying all these linguistic and stylistic devices enables the author of the article to convey the necessary factual and evaluative information about the researcher's experimental procedures discussed in the article.

In some cases, including the narratives about scientists' travel and/or research experience in the articles from *Discover* is also aimed at familiarizing the readers with the views of their authors and/or the researchers on the possible contribution which the research has made to the field. Some information about the researcher's interpretations and evaluations of the major observations and results of their studies can be found in these narratives as well:

Excerpt #6 (McClintock, 2004)

Widder has worked on it for a decade with no grant money and little help. Two years ago, she built a prototype and used a remote undersea vehicle to install it 6,400 feet deep in Monterey Canyon off the California coast. When she hauled it up, the case was flooded. "Success in life depends on how well you handle Plan B," she says. "Anybody can handle Plan A."

Plan B was to fix the leak and try again. This time she got pictures. At first, she was pleased. The fish didn't startle when the light came on, and she assumed they hadn't spotted it. But when she studied the film more carefully, she saw that when the light came on, the fish began to move away. So this year it's on to Plan C. She has no intention of failing to capture "the best light show on the planet" faithfully and unobtrusively. "We know so little

about these animals," she says. "I'm very interested to see what these bizarre displays are about, these totally bizarre behaviors we just don't understand yet." (para. 14-15)

In this narrative presented in the final part of the article "Splendor in the Dark" from *Discover*, a brief description of the final stages of the study discussed in the article is intermingled with several indications of the researcher's reactions and interpretations of her actual observations ("At first, she was pleased," "… she assumed they hadn't spotted it," and "she has no intentions of failing to capture "the best light show on the planet" faithfully and unobtrusively"). As this narrative is used at the very end of the article, it is quite logical that its final part contains a call for further research on the mechanisms of bioluminescence investigated in the study. The fact that this call for further research is expressed with the help of the direct quotation which conveys the researcher's words ("We know so little about these animals," she says. "I'm very interested to see what these bizarre displays are about, these totally bizarre behaviors we just don't understand yet") and which is used at the very end of the story makes the author's rhetorical appeals even stronger and more convincing. Introducing this and another direct quotation ("Success in life depends on how well you handle Plan B," she says. "Anybody can handle Plan A") and the metaphorical expression "the best light show on the planet" employed by the researcher herself makes the whole narrative both personalized and authentic at the same time.

Discussion and Conclusions

In the study discussed in this chapter, a descriptive analysis was conducted for exploring the use of the narratives about scientists' travel and/or research experience in the text of PSAs from *National Geographic* and *Discover*. Based on the observations presented above, it is

possible to conclude that, similar to the use of simile in PSAs, the use of this kind of narratives in the articles from these two magazines is characterized by some common and varying features. For example, in both magazines, this kind of narrative can be employed for providing the necessary contextual information and for familiarizing the readers with the most important aspects of the research described in the article. In addition, the authors of PSAs from both magazines tend to use the narratives about scientists' travel and/or research experience for conveying the researcher's and/or their own evaluations of the subject of the article and for making their narration vivid and dynamic. This corresponds with the observations described in Morgan and Wise's (2017) article, according to which introducing people's personal narratives into science discourse elicits those people's and the writer's personality, including their feelings, events, new associations and the decisions made. Thus, it is possible to assume that using this kind of narrative allows the authors of PSAs to make their scientific narration authentic and personalized.

At the same time, as shown by Moezzi, Janda, and Rotmann (2017) as well as by Stewart and Nield (2013), the narratives containing biographical and/or autobiographical elements allow science writers to increase the degree of public engagement in different areas of science; in this connection, the researchers come to the conclusion that the construction of a compelling narrative of this kind emerges as a central construct in science journalism and in other communicative situations involving the general public. Therefore, it is logical to assume that introducing the narratives about scientists' travel and/or research experience into the articles from *National Geographic* and *Discover* enables their authors to make the necessary scientific content accessible and engaging for the general public.

It is also possible to say that when the narratives analyzed in this study are used for providing the necessary contextual information and for familiarizing the readers with the most important aspects of the research, they serve as a "lead," since they provide the background information which should draw the readers' attention to the subject of the article. This corresponds with the demands of mass media and journalism which are based on the fact that newspapers and magazines must compete for a reader's attention in the open information market (Funkhouser & Macoby, 1970). Therefore, as Nwogu (1991) mentions in his study of the JRV (Journalistic Reported Version) of professional medical research reports, any journalistic writing which fails to take this need into account may lose the readers to numerous other competing stories from other texts included in that magazine. In addition, as shown by Zimmer (2013), the stories containing the elements of one's biography need to serve as a kind of map for the journey which the author of a popular science text (including the texts of PSAs) wants to take the reader on. This also resembles Gregory and Miller's (1998) conclusion, according to which the use of stories can help science writers organize their material so that they carry the readers through the article. Finally, as demonstrated by Stewart and Nield (2013), the narratives which are used as a "lead" provide the context by which non-specialist audiences can relate to and engage with more specialist knowledge related to a particular area of study (in our case, to ocean life research). This probably makes the content of popular science texts (including the texts of PSAs) attractive and memorable for their potential readers.

The existence of the above-mentioned invariant features of using the narratives about scientists' travel and/or research experience in the PSAs from *National Geographic* and *Discover* analyzed in this study points to the fact that all these texts belong to the genre of popular science article. At the same time, alongside the above-mentioned invariant features, the use of the

narratives about scientists' travel and/or research experience in the articles from *National Geographic* and *Discover* is characterized by certain varying parameters as well. Variations in the ways of using these narratives point to the fact that the target audience of the articles and specific purposes of the magazine where they are published need to be regarded as the contextual factors affecting the use of this kind of narrative in the text of PSAs. For example, it is not seldom when the authors of the PSAs from *National Geographic* resort to the use of this type of narrative for providing the necessary information about the major results and potential outcomes of one's research. This tendency can be probably explained by the fact that, since the articles published in *National Geographic* are addressed to different categories of readers (including those who may be not interested in the questions of science before they become familiar with the content of those articles), their authors need to use different rhetorical devices which would help them maintain the readers' interest and attention throughout the text of the whole article.

In addition, introducing the narratives about scientists' travel and/or research experience into the text of PSAs from *National Geographic* allows their authors to share with the readers their own and researchers' hypotheses, assumptions, personal opinions, emotions and impressions, based on their observations related to the subject of the article. This fits into Montgomery's (2003) observations, according to which using the stories about one's real-life experience allows the authors of popular science texts to get their readers involved on a personal level. As shown by Hyland (2010), this should also increase the level of proximity between the author and the potential readers of his/her article. At the same time, as mentioned by Petit, Mougenot and Fleury (2011) in their study about the use of stories in research writing, combining the author's description of his/her own or someone else's research experience and the

elements of storytelling becomes the "driving force of scientific work," well hidden behind the generic nature of scientific inquiry.

It follows from the results of this study that in the articles from *Discover*, the stories about scientists' travel and/or research experience are sometimes used in the author's descriptions of the processes of experimentation, data identification, selection and delimitation involved in one's research. Including this information in the articles from *Discover* is probably connected with the fact that they are intended for the readers who have a stronger background knowledge about certain areas of science and who have a more extensive experience of reading about science, compared to most of the potential readers of *National Geographic*. It is possible to say that in this case, the use of this kind of narrative makes the content of the PSAs from *Discover* informative and detailed, since, as it is discussed in Petit, Mougenot and Fleury's (2011) study, the stories which are directly associated with one's research are capable of producing elements of knowledge that otherwise may have remained unsaid and that will in turn draw out new elements. Thus, we can conclude that in such situations, the use of narratives enables writers to elaborate on the research procedures described in their PSAs in an engaging and vivid way.

It is also worth mentioning here that, according to Carriére's (2014) "11 Tips to Write Popular Science Articles," the use of one's life story lets the authors of PSAs make scientific findings attractive for the readers. This probably explains why the authors of the articles from *Discover* and especially from *National Geographic* analyzed in this study tend to employ the above-mentioned kinds of scientists' stories when sharing with the readers some information about researchers' observations or, for instance, when writing about the data collection or experimental procedure of a particular study. In such cases, their use allows science writers to

make their descriptions of data identification, selection and delimitation accessible to non-specialist audiences. Eventually, this should lead to increasing the level of proximity between the authors of PSAs and their readers as well.

The results of this study show that the narratives about scientists' travel and/or research experience can also be employed in the text of the articles from *Discover* for familiarizing the readers with the author's and/or researcher's views on the possible contributions of the study to the field. This goes well with Dahlstrom and Ritland's (2012) observations, according to which narratives, in essence, may represent "a method of packaging phenomena into human scale" (p. 127). In such a case, they often provide a possible remedy for the issues of communicating a meaningful sense of distant science topics which may not be familiar to the lay readers before they start reading the magazine where the article is published.

In some cases, introducing the narratives about scientists' travel and/or research experience into the final part of the PSAs from *Discover* also helps their authors make their rhetorical appeals even stronger and more convincing while increasing the degree of authenticity and personalization of their narration in general. This goes well with Zimmer's (2013) guidelines for science writers, according to which the stories introduced into the final part of one's popular science text can look towards the future, showing the directions of further research and some possible applications following from the results of the research described in the article. The fact that the use of narratives tends to make the author's ideas, judgements and statements persuasive can be explained by the fact that, since the narratives describe a particular experience rather than general truths, they have no need to justify the accuracy of the claims which they contain; the story itself demonstrates the claim (Dahlstrom, 2014; Moezzi, Janda, & Rotmann, 2017). In a similar way, the structure of narrative links its events into a cause-and-effect relationship; the

latter makes the conclusion of the narrative seem inevitable even though many possibilities could have happened (Curtis, 1994). This inevitability combined with the lack of a need for justification, supports the normative elements within a story (i. e., what is good and what is bad), without the necessity to clearly articulate or defend them (Graesser & Ottati, 1995). Because narratives are able to provide certain values to real-world objects without argument, it is difficult to counter their claims. This peculiar feature of narratives makes the readers of the articles believe that the factual and scientific information presented in them is valid and trustworthy.

At the same time, some researchers (e. g. Avraamidou & Osborne, 2009; Beatty, 2017; Katz, 2013; Morgan & Wise, 2017; Semino, 2008) point to the fact that when reframing one's scientific messages as stories in this way, science writers run the risk of oversimplification. Nevertheless, as shown by some other authors (e. g. Blyler, 1996; Gastel, 1983; Lazarevich, 1976; Moezzi, Janda, & Rotmann 2017; Montgomery, 1996; Schneider 2008; Stewart & Nield, 2013), the use of narratives in such cases serves the purpose of adjusting the message to suit the target audience of PSAs and other popular science texts; according to them, without resorting to simplification it is almost impossible to communicate the implications of one's scientific results to the general public. They all agree that the use of narratives allows science writers to convey the necessary scientific content in an accessible and engaging way, without having the risk of oversimplifying or falsifying scientific information. This shows the importance of introducing narratives into different structural parts of PSAs, including those rhetorical moves of PSAs where their authors describe the process of data collection/experimentation and where they present research conclusions.

The pragmatic and communicative functions of the narratives about scientist's travel and/or research experience discussed above are performed with the help of certain linguistic and

stylistic means deployed in the text of PSAs. The narratives introduced into the text of the articles from *National Geographic* and *Discover* are characterized by the simultaneous use of different linguistic means conveying mainly either factual or evaluative information. On the one hand, the use of scientific terms and their brief definitions, synonyms or explanations, abbreviations and proper nouns as well as numbers, different expressions for rounding numbers and quotations is mostly aimed at providing the necessary factual information. On the other hand, numerous evaluative lexical units, colloquial words, lexical intensifiers, modal verbs and idioms as well as different stylistic devices (namely, metaphorical expressions, the instances of exaggeration, comparisons and personifications) convey the elements of evaluative information. This tendency of combining the linguistic means conveying factual and evaluative information suggests close connection of the mental and emotional-evaluative components of the language mapping of the world reflected in the text of PSAs. Introducing the above-mentioned linguistic means expressing the elements of factual and evaluative information within one narrative helps the authors of the articles present the necessary factual and emotional or evaluative information in a compact and expressive way while forming in the reader's mind some new associations, emotions, thoughts, and ideas related to the topic of their article. Besides, as well as in some other kinds of popularized texts, including the texts of journal editorials (Giannoni, 2008), the use of metaphors, metaphorical comparisons, personifications, and some other stylistic means stimulates the readers of these articles to find logical connections between different elements of one and the same text; eventually, this should improve one's understanding of the factual information presented in a particular PSA.

Noteworthy, almost all narratives about scientists' travel and/or research experience identified in the corpus of the study contain at least one direct quotation conveying the

researcher's comments and remarks. The active use of direct quotations observed in the narratives from PSAs published in *National Geographic* and *Discover* enables their authors to influence the reader making him/her believe that the factual information and practical recommendations presented in their articles are valid and trustworthy. As shown in some previous research related to the linguistic and structural peculiarities of popular science texts, this way of using quotations and other markers of intertextuality is typical of PSAs (De Olivera & Pagano, 2006) and some other kinds of popular science texts containing some pieces of advice and practical recommendations, including popularized medical texts published in newspapers (Gallardo, 2005). At the same time, the results of the present study suggest that introducing direct quotations into narratives also lets the authors of PSAs reveal the researcher's voice while convincing the readers that certain hypotheses, judgements, opinions, and assumptions related to the questions discussed in those articles are generally true-to-life and well-justified. Besides, the use of quotations in different types of narratives increases their degree of coherence and authenticity which, according to Ochs and Capps (1996), are inherent properties of stories and ways of describing the narrator's experience of self.

The pragmatic and communicative functions as well as various linguistic features of scientists' narratives about their travel and/or research experience used in the texts of PSAs could be further investigated with the help of using questionnaires and interviews with the authors and/or readers of those articles. At the same time, investigating the use of some other kinds of narrative which tend to be introduced into the text of PSAs (e. g. the author's personal narratives about their experience connected with the research described in the article, the stories about certain episodes from the researcher's biography, etc.) would allow us to reveal some other tendencies observed in the use of this rhetorical device in the genre of PSA. This may include,

for example, the use of some other linguistic and stylistic devices in the other kinds of narrative serving the same or some other communicative and pragmatic purposes in the text of PSAs, depending on their structural part(s) where these narratives are typically employed, the subject of the article, the requirements and characteristics of a particular magazine, etc. Lastly, conducting further research into different types of narrative in the printed and online articles dedicated to the questions of ocean life and some other subjects would be useful in terms of examining the influence of various contextual factors (including the requirements of this or that magazine or Web-site, one's individual style of writing, the communicative and pragmatic purposes of the authors of PSAs, their target audience, subject, purpose, participants, and so on) on the frequency and ways of using certain rhetorical and linguistic means in the text of different varieties of PSAs.

CHAPTER V

CONCLUSION

The analysis conducted within this study shows that the frequency and ways of using different linguistic and rhetorical means may vary in the text of different varieties of PSAs. In particular, as shown in Chapter 2, the frequency and the range of the forms of introducing theory-constitutive metaphors is different in the text of the astronomy and biology articles investigated in this project. For example, in the astronomy articles, the concepts conveyed via the use of theory-constitutive metaphorical expressions are defined and/or explained more often than in the biology articles. In the biology articles, in many cases, the meaning of theory-constitutive metaphors can often be inferred from the context and the readers' previous background knowledge. In addition, the biology PSAs investigated in the present study are characterized by a smaller number of theory-constitutive metaphors and a more limited range of the forms of introducing new theory-constitutive metaphors, compared to the astronomy articles. As shown earlier, these tendencies can be correlated with the assumed degree of the readers' familiarity with the subject of these articles as well as with the current level of understanding of the phenomena studied by astronomers and biologists.

The results of the studies included in this dissertation project suggest that some other contextual factors can also have influence on the linguistic and rhetorical features of PSAs. For example, as follows from the results of the study presented in Chapter 3, the lexical structure of

similes and the frequency of using the similes with a different lexical structure could be different in the PSAs from *National Geographic* and *Discover*, depending on the authors' purposes, the assumed target audience, and specific requirements or characteristics of each magazine. For instance, while the similes which are mostly aimed at conveying the necessary factual information and which contain stylistically neutral nouns and adjectives, scientific terms and their synonyms prevail in the articles from *Discover*, the articles from *National Geographic* are characterized by a more frequent use of the similes containing evaluative adjectives and lexical intensifiers conveying the elements of evaluative or emotional information. These differences can be connected with the fact that the articles from *Discover* tend to include more factual information, while the PSAs from *National Geographic* usually contain more additional information (including the author's and/or researcher's evaluations) accompanying the necessary scientific information.

Furthermore, it is possible to infer from the results of the study discussed in Chapter 4, that in the PSAs from *National Geographic*, the stories about scientists' travel and/or research experience can be used for providing the necessary information about the major results and potential outcomes of one's research described in the article. At the same time, in the articles from *Discover* intended for the readers who are better familiar with certain areas of science, PSAs are sometimes used in the author's descriptions of the processes of experimentation, data identification, selection and delimitation involved in one's research. Similar to the observations described in Chapter 3, these differences in the use of scientists' narratives about their travel and/or research experience point to the fact the target audience of the articles and specific purposes of the magazine where they are published need to be regarded as the contextual factors affecting the use of this type of narrative in the text of PSAs.

Multi-functionality and variability in the use of the above-mentioned linguistic and rhetorical means employed in different varieties of PSAs determines the complex and changing nature of the language mapping of the world reflected in this kind of popular science literature. At the same time, in spite of some variations observed in the frequency and/or ways of using the linguistic and rhetorical devices discussed in this project, their use in the varieties of PSAs analyzed in this project is characterized by some invariant features as well. For example, certain methods of introducing theory-constitutive metaphors are commonly applied both in the astronomy and biology PSAs investigated in the study described in Chapter 2 (including the use of context and the readers' background knowledge, explicit definitions, and the explanations of the origin or etymology of theory-constitutive metaphors). Besides, in all articles analyzed within the study discussed in Chapter 2, the use of theory-constitutive metaphors is aimed, first of all, at presenting certain scientific phenomena and their particular aspects. In this connection, we can conclude that in both varieties of PSAs, theory-constitutive metaphorical expressions mainly serve the informative (cognitive) function.

The results of the study presented in Chapter 3 show that the use of simile in the PSAs from *Discover* and *National Geographic* is characterized by some invariant features as well. For example, in many cases, the authors of PSAs resort to similes for explaining new scientific terms which they introduce into their narration before using similes. This way they help the readers make some logical connections between the necessary scientific content and the objects and phenomena which should be familiar to the readers before they start reading the article. In some cases, the authors of the articles investigated in this study may also employ similes for sharing with the readers and emphasizing their own point of view about the questions discussed in their

articles. In this connection, we can conclude that in both varieties of PSAs, the similes with different kinds of lexical structure serve the informative (cognitive) and evaluative functions.

Finally, as demonstrated in Chapter 4, in the PSAs from both magazines (*National Geographic* and *Discover*), scientists' narratives about their travel and/or research experience can be employed for providing the necessary contextual information and for familiarizing the readers with the most important aspects of the research described in the article. In addition, the authors of PSAs from both magazines tend to use the narratives about scientists' travel and/or research experience for conveying the researcher's and/or their own evaluations of the subject of the article and for making their narration vivid and engaging. The existence of these invariant characteristics shows that, despite some differences in the ways of using these linguistic and rhetorical means in the text of PSAs investigated in this dissertation project, all these texts belong to the genre of popular science article.

The results of the studies discussed in Chapters 2-4 of this dissertation show that introducing such linguistic and rhetorical devices as theory-constitutive metaphors, similes and scientists' narratives about their research/travel experience into the texts of PSAs may help the authors of PSAs make communication between specialists and lay readers more effective. For example, it follows from the results of those studies that the use of metaphors and similes which serve to link an unknown phenomenon or concept to a more familiar one by comparing them, allow the authors of PSAs to make scientific content clear and accessible to the general public. This seems to match the recommendations provided by the authors of different guidelines for science writers (e. g. Ben-Ari, 1999; Carriére, 2014; Christensen, 2007; Ehrenstein, 2010; Gastel, 1983; Gregory & Miller, 1998; Joubert, 2011; Popular science writing, 2014; Rayl, 1992; Schmitt, 2013; Secrets of good writing, n.d.). According to them, the use of metaphors and

similes (and different kinds of analogies in general) leads to creating in the readers' mind mental images of the necessary concepts, which typically makes complicated notions and ideas seem simple. Therefore, as noted by Gastel (1983), using metaphors and other kinds of analogy is an especially helpful tactic for relating unfamiliar to familiar concepts. Creating such mental images also contributes to the compression of time, space, and events which are inherent in journalism and literature and which, according to Janovy (2010), lead to highly educational results, as this way the readers get an individual access to the compressed variant of primary scientific literature (for example, of the original scholarly article(s), monograph(s), etc.).

Interestingly, in some guidelines for science writers (e. g. Bucchi, 1998; Ngumbi, 2018; Pain, 2015; Scharf, 2013), it is also shown that the use of metaphorical expressions, narratives and comparisons enables the authors of popular science texts to describe and promote their own views, attitudes and opinions related to the subject of discourse in a convincing, accessible and vivid way. For example, as discussed by Ngumbi (2018), referring to whale songs as to "the soulful sounds" in a popular science text ("That hasn't kept the public from enjoying *the soulful sounds*, however, as several record companies have released albums featuring whale songs" (p. 34)) reflects its author's positive opinion about their quality and diversity.

This information about the major functions of using metaphor and simile in popular science texts corresponds with the research data discussed in Chapters 2-4. For example, it can be inferred from those data that theory-constitutive metaphors, similes and scientists' narratives about their travel/research experience can be used by the authors of PSAs for conveying the necessary factual and/or evaluative information to the lay readers in an accessible and vivid form. In particular, the results of investigating the use of simile in the text of PSAs from *National Geographic* and *Discover* show that including in similes stylistically neutral nouns,

well-known scientific terms or acronyms and, in some cases, colloquial vocabulary allows the authors of those articles to convey the necessary factual information in an interesting and engaging form. This goes well with the recommendations to use simple everyday conversational language which can be found in many guidelines for science writers (e. g. Ben-Ari, 1999; Carriére, 2014; Christensen, 2007; Zimmer, 2013). Furthermore, as discussed in Chapter 3, introducing the similes whose lexical structure includes evaluative vocabulary, colloquial words, word repetitions, lexical intensifiers, hedges, and the elements of exaggeration enables writers to make their arguments, personal opinions and evaluations noticeable in the text of the article as well as expressive and persuasive at the same time. According to Ehrenstein (2010) and Gregory and Miller (1998), employing the similes containing stylistically marked lexical units (e. g. evaluative and colloquial words, lexical intensifiers, etc.) makes scientific content palatable and accessible to non-specialist audiences. At the same time, the use of the similes whose lexical structure includes these linguistic devices mentioned above suggests close connection of the factual and emotional-evaluative information conveyed in the text of PSAs.

As noted earlier, most of the above-mentioned guidelines recommend science writers to use metaphor and simile (as well as other kinds of analogies) for conveying the necessary factual and evaluative information in an accessible and entertaining way. Only a few of them (namely, Christensen, 2007; Joubert, 2011; Khakhar, 2017) mention that, in some cases, the authors of popular science texts may need to explain the meaning of the metaphors and similes whose meaning may not be clear to the readers based on the context and/or their world knowledge. This seems to be especially relevant to the theory-constitutive metaphors which serve, first of all, as the scientific terms denoting certain objects and phenomena.

Noteworthy, the authors of some guidelines for science writers (e. g. Ben-Ari, 1999; Carriére, 2014; Ehrenstein, 2010; Gregory & Miller, 1998; Joubert, 2011; Popular science writing, 2014; Schmitt, 2013) also speak about explaining the meaning of metaphors and similes with the help of definitions. At the same time, the results of the research into the use of theory-constitutive metaphors and similes in the text of PSAs described in Chapters 1 and 2 suggest that in many cases, the authors of PSAs explain the meaning of the theory-constitutive metaphors and similes which they use in their articles in some other ways as well (especially in those cases when they have at their disposal more research data and more definite scientific information connected with the phenomena denoted by those metaphorical expressions). This probably allows them to make the necessary scientific content clear and accessible to the general public. For example, the authors of astronomy and biology PSAs typically avoid providing detailed definitions of theory-constitutive metaphors and of scientific terms in general. Instead of that, they tend to introduce new metaphors with the help of explaining their etymology or origin, mentioning only one or two important features of the necessary object or phenomenon, sharing with the readers their own evaluations and other additional details connected with a certain phenomenon, using the elements of personification and storytelling, comparing a scientific phenomenon with another process or phenomenon familiar to the lay readers, and some other devices which allow them to convey the necessary scientific information in a dense and compact form. This allows the authors of PSAs to convey the necessary scientific content in a compact, clear and easy-to-read way.

The results of the study discussed in Chapter 4 demonstrate that, in some cases, scientists' narratives about their research/travel experience can also be regarded as a device helping the authors of PSAs to make their narration compact and personalized. This tendency is

probably connected with the fact that, as mentioned by Janovy (2010), "compression of time, space, and events also is inherent in journalism and literature, even, if not especially, the kind of literature consumed by the general public today" (p. 97). In this connection, Janovy (2010) concludes that the use of stories allows science writers to compress decades of discovery into a few short sentences. This becomes especially important for the writers of PSAs, since they need to be able to convey the necessary scientific information in a compact but still accessible and entertaining form. Besides, as noted by Ben-Ari (1999), for many authors and readers of popular science texts, finding stories when writing or reading them, respectively, is one of the most (if not the most) interesting parts of familiarizing themselves with science. According to his observations, readers can usually sense the author's passion for the subject of his/her text; in this connection, he concludes that when the author of a popular science text tells a story in which he or she is a player in the action or which he knows about, the result can be particularly appealing. This corresponds with the fact that, as follows from the results of the research described in Chapter 4, in the text of PSAs published in *National Geographic* and *Discover*, the narratives about scientists' travel/research experience can be used for different communicative and pragmatic purposes, including presenting background information as well as presenting new research and indicating consistent observations. In such cases, the use of this kind of narratives in the text of PSAs helps their authors present the necessary factual information in a logical and accessible way.

The analysis conducted within the studies described in Chapters 2-4 may have some important implications for science journalists and scientists reporting research to non-specialist audiences. For example, the results of the studies presented in Chapters 2-3 show that the theory-constitutive metaphors and metaphorical comparisons employed in PSAs are useful because they

distill the important components of a scientific idea and allow both experts and non-experts to refer to certain natural processes and phenomena. It also follows from the findings of these studies that in many cases, the use of these linguistic devices in the texts of PSAs enables their authors to connect certain scientific phenomena to something more familiar, allowing the readers to understand the necessary scientific content based on their world knowledge.

At the same time, the observations presented in Chapters 4 point to the fact that the use of the narratives about scientists' travel and/or research experience allows the authors of PSAs to balance their dual goals of reporting objective and accurate factual and scientific information, on the one hand, and conveying the researchers' and the authors' personal evaluations and opinions, on the other hand. In addition, as shown by Parkinson and Adendorff (2004), narratives could be effectively used as a bridge between narrative thinking and the logico-scientific mode of thinking. However, as some researchers (e. g. Gilbert, Hipkins, & Cooper, 2005) note, since the stories used in popular science texts may not be scientific enough, there is a need to come up with "science stories that involve real people (with real feelings and motivations) solving real problems, in ways ordinary people can empathize with" (p. 13). The results of the study presented in Chapter 4 suggest that the narratives introduced into PSAs could probably perform the function of such a bridge between narrative thinking and the logico-scientific mode of thinking, since they are normally based on the researcher's personal travel and/or research experience and since they usually contain much information about the researcher's (and sometimes also the author's) biography.

Furthermore, introducing narratives into different structural parts of PSAs enables their authors to remain economically viable by drawing and maintaining the fleeting attention of the lay audiences which these articles are intended for. In addition, as shown by Glaser et al. (2009),

due to the factors that narratives offer, – namely, dramatization, emotionalization, personalization, and fictionalization, – they are and can be effectively used in service of science education and science popularizations. Since narratives align with the organizational and structural needs of both informative and entertainment media systems and since they are ubiquitous across most media platforms, including popular science magazines (Dahlstrom, 2014), it is logical to conclude that they represent the dominant form of science communication which non-expert audiences are receiving. Besides, according to Carriére's (2014) "11 Tips to Write Popular Science Articles," the use of one's life story lets the authors of PSAs make scientific findings attractive for the readers. This probably explains why the authors of the articles from *Discover* and especially from *National Geographic* analyzed in Chapter 4 tend to employ scientists' narratives about their previous travel/research experience when sharing with the readers some information about researchers' observations or, for instance, when writing about the data collection or experimental procedure of a particular study. In such cases, their use allows science writers to make their descriptions of data identification, selection and delimitation accessible to non-specialist audiences. Eventually, this should lead to increasing the level of proximity between the authors of PSAs and their readers as well.

It also follows from the findings of the studies presented in Chapters 2-4 that in some situations, the readers' previous knowledge and the information presented in the text of PSAs may not be sufficient for achieving an adequate understanding of the scientific content presented in them. In such cases, providing additional clues, including the synonyms of scientific terms or the use of the terms familiar to the general public, should help the readers associate those new scientific terms with the processes/phenomena and their particular characteristics which are denoted by them. In addition, sharing with the readers the author's evaluations or other

additional details with the help of the metaphorical comparisons and the narratives containing evaluative adjectives, lexical intensifiers and mitigating devices, word repetitions and the elements of exaggeration enable the authors of PSAs to convey the necessary scientific content in a vivid and engaging way. Eventually, the use of these linguistic and rhetorical means should help their readers achieve an adequate understanding of the phenomena denoted by them, and hence of the subject of the articles where they are employed. This fits well into Ehrenstein's (2010) suggestion, according to which in those cases when one's initial variant of popular science text seems too wordy and abstract, it can usually be improved by adding a story, metaphor, simile or personification creating a certain mental image and the related associations in the reader's mind. Thus, it is possible to conclude that in many cases, introducing metaphors (including theory-constitutive metaphors), similes and scientists' narratives about their travel/research experience into the text of PSAs allows their authors to make scientific results informative, intelligible and interesting to a general readership.

Alongside the above-mentioned implications for the scientists and science journalists writing PSAs, the results of the studies presented in this dissertation may also have some important pedagogical implications. In particular, discussing and analyzing the examples of the theory-constitutive metaphors, similes and narratives introduced into the texts of PSAs at ESL/EFL (English as a second/foreign language) lessons can help learners enrich their own range of various linguistic and rhetorical means which they can construct themselves and which they can apply then in different communicative situations (for example, when trying to persuade somebody that their point of view is well-justified and true-to-life, or when presenting the necessary factual information in a logical, coherent and engaging way, and so on). The examples of the similes with different lexical structure and the narratives employing different linguistic

means as well as different ways of introducing theory-constitutive metaphors into the text of PSAs can also be effectively used for developing some activities aimed at teaching students how to separate factual information from the author's personal judgments, opinions, hypotheses, etc.

The results of the studies described in Chapters 2-4 and some other related studies (e. g. Avraamidou & Osborne, 2009; Parkinson & Adendorff, 2004, etc.) also suggest that the metaphors, similes and narratives employed by science writers can make science accessible and meaningful to students, which means that they can play a useful role in the teaching of scientific writing as well as in the teaching of science. They can also become a good base for developing students' skills of writing a narrative essay, participating in a scientific dispute or discussion, or presenting scientific information in such a way that it could be clear and accessible to non-specialist audiences as well.

In addition, introducing the examples of the metaphorical expressions, similes and narratives from PSAs into ESL/EFL or ESP/EAP (English for Specific/Academic Purposes) lessons can help English language teachers demonstrate to their students that the same linguistic and rhetorical devices can perform different functions in different kinds and varieties of the same kinds of texts (including the texts of PSAs), depending on various contextual factors. As shown in Chapters 2-4, these factors may include such aspects as the subject of a concrete article, the author's assumptions about the degree of the reader's familiarity with the topic of his/her article and with the meaning of the scientific terms introduced into it. The author's communicative and pragmatic purposes as well as the requirements and specific characteristics of a particular magazine may also have impact on the use of the linguistic and rhetorical devices investigated in this dissertation project. In this connection, it is possible to conclude that focusing on the differences observed in the use of metaphors, similes and narratives in PSAs should enable

EFL/ESL and ESP/EAP teachers to emphasize the necessity to consider various contextual factors which may influence the ways of using theory-constitutive metaphors, similes and scientists' stories about their travel and/or research experience in one's speech or writing. It is also logical to assume that the PSAs containing these linguistic and rhetorical means can be used by EFL/ESL and ESP/EAP teachers for showing their learners how to infer the meaning of new terms and the author's evaluations or interpretations, based on different clues provided in similes (for example, the presence of the comparison markers "like," "as," "as if" or "as though," evaluative adjectives, colloquialisms, synonyms of scientific terms, etc.).

Finally, as mentioned earlier, using theory-constitutive metaphors, similes and scientists' narratives about their travel/research experience allows the authors of PSAs to balance their dual goal of reporting objective and accurate scientific information and their own and/or the researchers' personal evaluations, judgments, and assumptions. This tendency can be used by ESP/EAP practitioners when teaching their students different strategies of presenting scientific information in such a way that it could be interesting and clear for non-specialist audiences as well. These strategies may include constructing and using similes containing stylistically neutral words and well-known terms familiar to the general public for showing the connections between different terms and concepts introduced into one's writing or speech, as well as for making one's scientific narration vivid, expressive and engaging for the lay readers or listeners.

The results of the analysis conducted within the studies described in Chapters 2-4 of this dissertation also contribute to the research into typological linguistic and rhetorical parameters which would help us distinguish between PSAs and other kinds of popular science literature. These parameters include, first of all, the typical forms of introducing theory-constitutive metaphors into the text of PSAs discussed in Chapter 2 (e. g. with the help of definitions and

explanations of the origin or etymology of a particular metaphor/metaphorical expression as well as based on the context and the assumed readers' previous background knowledge about the subject of the article). In addition, certain peculiarities of the lexical structure of similes employed by the authors of PSAs as well as the communicative and pragmatic purposes performed by scientists' narratives about their travel and/or research experience in PSAs can also serve as the typological linguistic and rhetorical parameters peculiar to the text of PSAs. For example, as shown earlier, in many cases, the text of PSAs includes the similes which contain stylistically neutral nouns/adjectives, acronyms, scientific terms and their synonyms, or colloquial words. Their use enables writers to convey the necessary factual information related to the subject of their articles in an illustrative and accessible way. At the same time, introducing the similes whose lexical structure contains evaluative adjectives, lexical intensifiers, and/or mitigating devices allows the authors of PSAs to share with the readers and emphasize the researcher's and/or their own point of view about the questions discussed in their articles. The use of scientists' narratives about their travel and/or research experience combining the elements of some factual and evaluative information about different stages of the research presented in the article can be regarded as another typological parameter of PSAs revealed in this dissertation project.

Certain methodological implications may follow from the results of this dissertation project as well. For example, applying the model for investigating the ways of introducing theory-constitutive metaphors into the text of PSAs suggested in Chapter 2 (e. g. with the help of context, definitions, personifications, comparison with well-known processes and phenomena, etc.) can prove useful for investigating the use of additional clues helping the authors of PSAs and other popular science texts dedicated to different subjects introduce new terms and concepts

in a clear and adequate way. At the same time, the simultaneous study of the lexical structure of similes performing the factual and evaluative function (as demonstrated in Chapter 3) allows us to understand better how the authors of PSAs can balance their dual objective of sharing with the readers the necessary factual and evaluative or emotional information in an accessible and vivid form. This can probably also refer to some other linguistic or stylistic devices employed for providing the necessary factual and evaluative information in the text of PSAs, such as conventional and novel metaphors, personifications, allegories, etc. Finally, examining certain linguistic and stylistic means within the narratives in which they are used can be useful for investigating the communicative and pragmatic purposes performed by them in the actual discourse in which they are employed (including the PSAs and other popular science texts published in different sources, dedicated to different categories of non-specialist audiences, etc.). All these methodological implications point to the importance of investigating the language of PSAs in close connection with their content and the contextual factors which may influence their rhetorical features (e. g. the subject of the article and the assumed degree of the readers' familiarity with it, the requirements and characteristics of a particular magazine, its intended audience, one's individual style of writing, etc.).

Along with the above-mentioned theoretical, methodological, practical and pedagogical implications, several methodological limitations and suggestions should be noted here too. First of all, the results of the studies discussed in Chapters 2-4 cannot be generalized to other varieties of PSAs, as they are based on investigating only the articles dedicated to particular subjects or topics (e. g. astronomy, biology, or ocean life research). So limiting the research outcomes to those varieties of PSAs which were analyzed in these studies should make their interpretations more valid. The use of some other data sources and increasing the corpus of PSAs are also

recommended. The pragmatic and communicative functions as well various linguistic features of the similes and narratives introduced into the texts of articles could be further investigated with the help of using questionnaires and interviews with the authors and/or readers of those articles. Lastly, conducting further corpus-based research of the printed and online articles dedicated to biology, astronomy, and some other subjects would be useful for arriving at a better understanding of the ways in which various contextual factors (including the requirements of this or that magazine or Web-site, one's individual style of writing, the communicative and pragmatic purposes of the authors of PSAs, their target audience, subject, purpose, participants, and so on) may influence the frequency and ways of using certain linguistic and stylistic means in the text of different varieties of PSAs.

The above-mentioned limitations of the studies described in Chapters 2-4 suggest some possible directions for further research into the linguistic and rhetorical features of PSAs and the major benefits of using this kind of text in EFL/ESL and ESP/EAP teaching. First of all, further investigation of different invariant and varying structural, pragmatic and linguistic parameters observed in the texts of printed and online PSAs dedicated to different subjects and fields of study would be desirable for getting a better understanding of the conceptual and language mapping of the world reflected in this genre. At the same time, comparing the range, frequency, and ways of using different linguistic means and stylistic devices (for example, scientific terms, colloquialisms or evaluative adjectives as well as similes, metaphors, personifications, allegories, etc.) in different structural parts of PSAs and of some other kinds of popular science and popularized texts (including the texts of essays, journalese, science news, editorials, journalistic reported versions (JRVs) of research articles, science blogs, etc.) would make it possible to reveal various rhetorical and linguistic characteristics differentiating this or that genre of popular

science literature from some other kinds of popular science writing. This information could be useful for preparing new guidelines (or updating the previous ones) for the science journalists and scientists writing PSAs. Finally, further research into the structural, pragmatic, and linguistic characteristics typical of PSAs would be useful for developing and practical testing of some possible ways of using PSAs for different kinds of ESL/EFL and especially ESP/EAP projects and creative tasks (including simulations, role plays, student research activities and presentations, different kinds of essays and other writing assignments, various communicative activities, etc.).

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APPENDICES

APPENDIX A: List of the Theory-Constitutive Metaphors Revealed in the Astronomy and Biology PSAs

The astronomy articles	The biology articles
"dark energy," "dark matter," "black hole," "Big Bang," "Big Crunch," "Big Rip," "Big Chill," "Big Freeze," "Milky Way," "Great Red Spot," "Red Giant," "Doomed Star," "flare star," "shell star," "dwarf planet," "White Dwarf," "Sagittarius Dwarf," "Yellow Dwarf," "black moon," "blue moon," "blueshift," "redshift," "event horizon," "red storm," "push and pull of gravity," "gravitational pull," "heat death of the universe," "super-Earths," "elliptical galaxy," "ring-like galaxy," "spiral galaxy," "lenticular galaxy," "space elevator," "warp drive," "space walk," "moon illusion," "Retrograde Motion," "Retrograde Orbit," "radiation belt," "Kuiper Belt," "meteor shower," "stone meteorite," "star cluster"	"genetic make-up," "the (digital/natural) code of life," "text/book of life," "genetic letters," "building blocks," "building stones of life," "molecular blueprints of life," "transport," "translation," "messenger" (in relation to DNA and RNA), "neural networks," "switching circuits," "spin glasses," "software," "technology/machine" (in relation to organism or DNA), "cells" (in relation to the organism of living beings), "the animal kingdom," "wingtip path," "signature whistles" (in relation to dolphins), "second-order/third-order alliances" (in relation to the relationships between dolphins), "seafloor," "host species"

APPENDIX B: Formulas Applied for the Search of the Similes with a Different Lexical Structure with the Help of the UAM Corpus Tool

Formula	Comparison marker(s)	Characteristic elements of the similes found with the help of the formula
[tag="nn *"][word="like"]	"like"	stylistically neutral nouns, scientific terms and their synonyms, acronyms, colloquial words, word repetitions
[tag="nn *"][word="as"]	"as," "as if," and "as though"	stylistically neutral nouns, scientific terms and their synonyms, acronyms, colloquial words, word repetitions
[tag="adj *"][word="like"]	"like"	stylistically neutral adjectives, evaluative adjectives, colloquial words, word repetitions, elements of exaggeration

[tag="adj *"][word="as"]	“as,” “as if,” and “as though”	stylistically neutral adjectives, evaluative adjectives, colloquial words, word repetitions, elements of exaggeration
[tag="adv *"][word="like"]	“like”	lexical intensifiers, colloquial words, word repetitions, elements of exaggeration, mitigating devices (hedges)
[tag="adv *"][word="as"]	“as,” “as if,” and “as though”	lexical intensifiers, colloquial words, word repetitions, elements of exaggeration, mitigating devices (hedges)

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