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WHEN ASTROPHYSICS MEETS LAY AND SPECIALIZED AUDIENCES: TITLES IN POPULAR AND SCIENTIFIC PAPERS

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ABSTRACT

In this study we carry out a comparative analysis between titles of research papers published in the most authoritative specialized European and US-based astrophysics journals written in English and titles of articles on astrophysics published in *Scientific American Magazine*, the most prestigious English-written journal in the divulgation of science. We specifically address issues related to three linguistic variables: title length, title lexical density and title type. Our main results show that titles of research papers published in scientific journals are much longer than titles of articles published in *Scientific American Magazine*. Lexical density is also higher in scientific titles than in popular science ones. *Scientific American Magazine* titles are formulated in a clear and direct way, with no syntactic complexity. They consist primarily in simple and nominal constructions with a low presence of adjectives, compound groups and technical terminology. The predominance of nominal compounds over adjectival ones and the use of proper names, which mainly refer to well-known stars, planets, satellites and galaxies, imply that popular science titles usually deal with more global and well established concepts. The higher number of verbal titles and of definite articles in popular science titles when compared to scientific titles may also be interpreted as a greater desire to generalize the ideas presented. This study may be applied to languages other than English and would surely be of the utmost importance to determine the design of titles of scientific and popular science papers, not only in astrophysics but also in other fields.

Keywords: astrophysics, English, *Scientific American Magazine*, specialized journals, titles

INTRODUCTION

Titles are a front and summary matter (Swales, 1990) in the sense that they are both the first encounter between readers and any type of document, whether it is a research article, a thesis, a conference paper, a review paper, etc., and the main indicator of its content (Diener, 1984; Hartley, 2008; Soler, 2011; Yitzhaki, 1994). Due to the steady growth of papers published either in print or on online, titles must capture the reader's eye to the point from which s/he decides whether a text is worth reading or not. Thus attractiveness is not the only thing that matters in title formulation. Titles should also be clear, concise, independent and self-explanatory (Ball, 2009; Day, 1995; Gesuato, 2009; Haggan, 2004; Hartley, 2008; Swales & Feak, 1994) in order to accurately orient the reader to the

concept(s) under discussion in the papers that follow. As a matter of fact, precision, accuracy, economy and conciseness are the features of titles to which most scientific journal editors refer in the 'instructions for contributors' section of their journals (Haggan, 2004; Soler, 2007; Yakhontova, 2002). Moreover, the more precise and accurate a title is, the easier it is for bibliographers to compile data for indexing, abstracting and other documentation purposes. The importance of titles in the academic world has thus provoked that titling practices have been the object of a significant amount of research addressed by applied linguists, information scientists and psychologists, the main interests being placed in mono- and multi-disciplinary standpoints. Multi-generic and multi-linguistic perspectives have also been approached although to a lower degree.

Mono-disciplinary Studies

The field of medicine has been very productive for mono-disciplinary research on titles. Goodman (2000) asserted that titles of clinical trial reports were becoming more informative, whereas Goodman, Thacker and Siegel (2001) noted that editors occasionally modified titles of medical research articles in order to increase their clarity and informativity. McGowan and Tugwell (2005) recommended using informative titles in **c**linical **e**pidemiology and Cook, Beckman and Bordage (2007) also claimed that informative titles facilitated reading and searching literature in medical education. Along the same lines, Ubriani, Smith and Katz (2007) suggested that titles should include the study design in order to better enable editors, reviewers and readers to assess critically the articles published in clinically-oriented dermatology journals. Wang and Bai (2007) observed that nominal groups were widely used in medical research paper titles while Jacques and Sebire (2009) discovered a positive correlation of citations and title length in generalist and specialist medical journals. Jaime-Sisó (2009) found differences in the number of full sentence titles of biomedical articles and Cianflone (2010) demonstrated that nominal and compound structures were preferred in the titles of research papers published in veterinary medicine. Salager-Meyer, Alcaraz Ariza and Luzardo Briceño (2013), on their side, showed that medical case report titles have been steadily increasing in length, syntactic complexity, semantic richness and title type diversity.

Other scholars also adopted the mono-disciplinary perspective to approach the studies of titles. For instance, Anthony (2001) recorded statistically significant differences in citation rates of research article titles in computer science, and Cheng, Kuo and Kuo (2012) revealed that compound titles constituted more than half of the occurrences of research article titles in applied linguistics. Paiva, Lima and Paiva (2012) found that short-titled articles of papers retrieved from Public Library of Science journals and Biomed Central had higher viewing and citation rates than long-titled articles, whereas Krajnović and Omrčen (2013) disclosed that nominal group titles were the most frequent type of structural construction in articles published in kinesiology. Finally, Kumar (2013) discovered that full sentence titles were not a common occurrence in engineering journals and Méndez, Alcaraz and Salager-Meyer (2014) demonstrated that titles of astrophysics papers were mainly of the nominal and simple type.

Multi-disciplinary Studies

Among the scholars that examined titles from a multi-disciplinary standpoint, we can cite Dillon (1982), who noticed a steady increase in the use of colons in research article titles in education, psychology and literary criticism. Hartley (2007a; 2007b) found that the use of colons was greater in the arts than in the sciences and their use had no effect upon their subsequent citation rate. Lewison and Hartley (2005) also registered that in biology, biomedical research, chemistry, clinical medicine, earth and space, engineering and

technology, mathematics, oncology and physics, titles with colons were longer and more informative than those without them. Likewise, Ball (2009) observed a growing usage of question titles in life sciences, medicine and physics, while Jamali and Nikzad (2011) recorded small but significant differences between articles with different types of titles in terms of downloads and citations in the field of life and medical sciences.

Other researchers adopted the multi-disciplinary perspective when studying titles. Yitzhaki (1994, 2002) discovered that the correlation between title and paper length and number of authors was moderate in scientific fields, low in the social sciences, and inexistent in the humanities. Fortanet, Posteguillo, Coll and Palmer (1998) found that research paper titles were longer in chemistry than in computer science, business and economics and linguistics. Haggan (2004) reported differences and similarities in the syntactic and structural choices in research article titles in literature, linguistics and science. Afful and Mwinlaaru (2010) noticed that lexical density, length, structural organization and syntactic encoding in titles of conference papers published in education and applied linguistics varied according to individual authors' preferences. Pułaczewska (2010) observed that titles of research articles in the humanities tended to be more creative and less informative than titles in exact sciences and medicine.

Multi-generic and Multi-linguistic Studies

Some studies framed within the multi-generic perspective are worth commenting upon. For example, Sagi and Yechiam (2008) showed that regular and comment articles with highly amusing titles published in psychology received fewer citations than those with more neutral titles, while Gesuato (2009) found that similarities outweighed differences among the titles of books, research articles, dissertations and proceedings papers in the field of linguistics. Jalilifar (2010) noticed that thesis titles were more informative and structurally-varied than research article titles in applied linguistics, and Cianflone (2013) observed a preponderance of nominal and compound layouts and a lack of question titles in research articles, short communications and poster presentations in the field of food science.

In the sphere of multi-linguistic research, Nord (1995) recorded a lack of culture-specific variations in titles of poems and scholarly articles written in English, French, German and Spanish. Busch-Lauer (2000) compared titles in linguistics and medical research articles and conference papers written in German and English. She observed that linguistics titles were shorter than medical titles, and that German titles were shorter than English ones. Yakhontova (2002) found that in linguistics and applied mathematics compound titles of conference presentations in English were more numerous than in Russian and Ukrainian. Soler (2007, 2011) reported that in social and biological sciences research paper titles were longer than review paper titles and that in social sciences research paper titles written in English were shorter than those written in Spanish. Alcaraz-Ariza and Salager-Meyer (2012) demonstrated that syntactic and structural similarities outweighed differences in titles in neurology research papers written in English and Spanish. Hartley (2012) proposed different ways to improve the writing of titles in English and Spanish articles in clinical and health psychology.

To sum up, the vast and rich literature on titling practices has approached their studies from a wide range of perspectives. Nevertheless, all the studies have exclusively focused on the academic world and it seems that the subject has not been addressed in the non-academic world although the transfer of specific knowledge to non-specialized audiences has been widely examined (e.g. Alcíbar Cuello, 2004; Calsamiglia & Van Dijk, 2004; Cartellier, 2010; Ciapuscio, 2005; Villaroya, 2013).

PURPOSE AND CORPUS

Our main purpose in this investigation was to extend our previous study on research paper titles in astrophysics (Méndez, Alcaraz, & Salager-Meyer, 2014) by identifying possible differences between them and titles of astrophysics articles published in popular science journals. To this end, we compared scientific titles collected from the most authoritative astrophysics journals (*The Astrophysical Journal*, *Monthly Reports of Astrophysics*, *Astronomy and Astrophysics* and *Astronomical Journal*), and popular science titles from *Scientific American Magazine* (*SciAm*), the most prestigious English-written journal in the divulgation of science. In the case of *SciAm*, we examined all the titles related to astrophysical matters from the printed issues published in a 25-year period (1990-2014). Since the collected sample amounted to 329 titles, we gathered the same number of titles from the referred specialized journals (*SpJs*). As 1998 was the freely accessible online year shared by the scientific journals, we chose it as our initial collecting date. A total of 658 titles were analysed.

METHODOLOGY

We established three different title categories and recorded the following linguistic and syntactic variables in each title: title length, title lexical density, and title type.

Title Length (counted as the number of running words)

We manually counted all the words included in the titles. We defined the concept of 'word' as the unit occurring between spaces. Each semantic component in capitalized abbreviations was counted as one word. For example, 'SDO' (<Solar Dynamic Observatory) was counted as three words. Acronyms (abbreviations with syllabic structures that are usually pronounced as words and not letter-by-letter) and shortenings were counted as one word. For example, 'CHARA' (<Centre for High Angular Resolution Astronomy) and 'Cas' (<Cassiopeia) were counted as one word each. Like in capitalized abbreviations, each semantic component of hyphenated words was taken into account. 'Post-outburst', for instance, was counted as two words.

Title Lexical Density

In order to determine title lexical density, i.e. the amount of information conveyed by titles, we made a distinction between lexical or content words (nouns, adjectives, adverbs, past and present participles, mathematic and chemical symbols, conjugated and infinitive verbs) and grammatical or function words (auxiliary verbs, determiners –definite and indefinite articles, possessives–, conjunctions, prepositions, pronouns, and *wh*-words). Other word class items were not found in our corpus. Here-below are two examples drawn from both scientific and popular science titles that illustrate content and function words;

> Example 1: Golden gravitational lensing systems from the Sloan Lens ACS Survey – II. SDSS J1430+4105: a precise inner total mass profile from lensing alone (*SpJs*)
>
> Example 2: Young Suns (*SciAm*)

Title Type

Sentence boundaries, identifiable by the presence of punctuation marks, allowed us to establish a first distinction between 'simple' and 'compound' titles. A simple title (Examples 3 and 4) consists of a general heading and a compound title (Examples 5 and 6) comprises a general heading followed by a specific theme which may be separated by a colon, a comma, a dash, a full stop, a semi-colon or written on two different lines;

> Example 3: Excitation of an outflow from the lower solar atmosphere and a co-temporal EUV transient brightening (*SpJs*)
>
> Example 4: The Galileo Mission (*SciAm*)
>
> Example 5: The molecular gas content of z < 0.1 radio galaxies: Linking the active galactic nucleus accretion mode to host galaxy properties (*SpJs*)
>
> Example 6: Mercury: the Forgotten Planet (*SciAm*)

We established a second title type distinction, which is non-excluding with the previous one and which refers to 'nominal' and 'verbal' titles. A nominal title, which is also called 'indicative' or 'descriptive' (Fischer & Zigmond, 2004; Goodman, 2000; Huth, 1999; Jamali & Nikzad, 2011), is a more or less expanded nominal phrase that gives a straightforward presentation of the object of the study. On the contrary, a verbal title, also referred to as 'assertive sentence title' (Rosner, 1990), 'conclusion title' (Fischer & Zigmond, 2004), 'declarative' (Jamali & Nikzad 2011; Smith, 2000), 'declaratory' (Goodman, Thacker & Siegel, 2001; Smith, 2000), 'full sentence title' (Haggan, 2004; Jaime-Sisó, 2009; Soler, 2007, 2011), 'informative' (Goodman, 2000; Huth, 1999; McGowan & Tugwell, 2005) or 'verbal-clausal construction' (Hartley, 2008), contains an active verb with a full sentence that usually states the findings or the conclusion of the research being reported, very much along the lines of newspaper headlines. Nominal and verbal constructions may also be phrased in the interrogative form as the following titles illustrate;

> <u>Nominal/question</u>
> Example 7: An optical and HI study of NGC 5850: Victim of a high-speed encounter? (*SpJs*)
>
> Example 8: Why So Blue? (*SciAm*)
>
> <u>Verbal/question</u>
> Example 9: What is missing from our understanding of long-term solar and heliospheric activity? (*SpJs*)
>
> Example 10: Does Dark Energy Really Exist? (*SciAm*)

RESULTS AND DISCUSSION

Linguistic Variables

As Table 1 shows, scientific titles are much longer than popular science ones, a fact that should come as no surprise since one of the most important features of a scientific title is to summarize the body of a paper with the highest precision and accuracy. *SpJs* titles also have a mean count attested at 13.76 words per title, with a standard deviation of 30.36, whereas the mean count test of *SciAm* titles is of 4.27 words per title, with a standard deviation of only 2.89. In other words, the length of popular science titles is spread out over a range of values lower than that of scientific titles.

Table 1. Linguistic variables

Linguistic variables	*SpJs*	*SciAm*
Number of titles	329	329
Word length	4526	1404
Word average	13.76	4.27
Number of content words	3454 (76.31%)	950 (67.66%)
Number of function words	1072 (23.69%)	454 (32.34%)

Table 1 also displays that although content words outnumber function words in both corpora, the percentage of content words is higher in scientific titles than in popular science ones. As it happens with their length, the greater number of content words in scientific titles is once more linked to their higher accuracy and conciseness.

According to Table 2, the content words that come first in the two different samples are regular nouns and qualifying adjectives. However, some differences have been observed between *SpJs* and *SciAm* titles. The percentage of nouns (regular and *-ing*) is lower in scientific titles (61.73%) than in popular science ones (64.43%), which introduce more global concepts.

Table 2. Content words

Content words	*SpJs*	*SciAm*
Regular nouns	2102 (60.86%)	607 (63.90%)
Qualifying adjectives	1084 (31.38%)	221 (23.26%)
-ed adjectives	74 (2.14%)	14 (1.47%)
-ing verbs	50 (1.45%)	32 (3.37%)
Symbols	39 (1.13%)	0 (0%)
-ing adjectives	38 (1.10%)	8 (0.84%)
-ing nouns	30 (0.87%)	5 (0.53%)
Adverbs	27 (0.78%)	28 (2.95%)
Regular verbs	10 (0.29%)	35 (3.68%)

Proper of astrophysical terminology are abbreviations, acronyms, numbers, eponyms (names of individuals) and toponyms (names of places). Since scientific titles belong to a specialized discourse, it should come as no surprise that the percentage of titles with terminology (24.38%) is much higher than in the popular science sample (9.05%). A point worth commenting upon is that eponyms in *SpJs* titles are applied to astronomical devices, whereas proper names in *SciAm* ones refer mainly to usually well-known stars, planets, satellites and galaxies.

Example 11: Infrared array photometry of bulge globular clusters. I. Combined ground based JK and HST VI photometry of NGC 6553 (*SpJs*)

Example 12: Venus revealed (*SciAm*)

In example title 11, the letters 'J', 'K', 'V', and 'I' designate different filters of the photometric system, whereas the abbreviation HST stands for 'Hubble Space Telescope', which is named after the American astronomer Edwin Powell Hubble, and the abbreviation NGC stands for 'New General Catalogue' of Nebulae and Clusters of Stars.

Very often both scientific and popular science titles include compound groups (nominal and/or adjectival ones), which are compressed structures where information is usually condensed through the juxtaposition of content words without any function word, as is shown in the following titles:

> Example 13: The extended ROSAT-ESO Flux Limited X-ray Galaxy Cluster Survey (REFLEX II) – IV. X-ray luminosity function and first constraints on cosmological parameters (*SpJs*)

> Example 14: Asteroid Hunters (*SciAm*)

Noteworthy is the fact that the compound group average is much higher in scientific titles (1.6 per title) than in popular science ones (0.24 per title). This finding is directly related to the syntactic complexity and semantic richness of *SpJs* titles.

In regard to adjectives (qualifying, *-ed* and *-ing*), which are directly related to more specialized concepts, their percentage is higher in *SpJs* titles (34.62%) than in *SciAm* ones (25.57%). Qualifying adjectives may be formulated in comparative and superlative forms although the frequency of occurrence differs from one sample to another. Comparative and superlative adjectives were found in scientific titles only on five (0.47%) and two (0.19%) occasions, respectively. By contrast, popular science titles contained seven (3.17%) comparative adjectives and five (2.26%) superlative adjectives. The fact that popular science titles contain more adjectives formulated in comparative and superlative forms may be considered a sign of higher emotional involvement. Here-below are examples of both types of adjectives:

> Example 15: The lower main sequence of the globular cluster M3 with the Hubble Space Telescope: Luminosity and mass functions (*SpJs*)

> Example 16: Deeper Impact (*SciAm*)

> Example 17: Temperature constraints on the coldest brown dwarf known: WISE 0855-0714 (*SpJs*)

> Example 18: The Ghostliest Galaxies (*SciAm*)

The percentage of verbs (*-ing* and regular), which are used to express generalizations, amounts less than four times in scientific titles (1.74%) than in popular science ones (7.05%). Symbols, either chemical or mathematical, generally belong to specialized discourses and this is why they are only present in *SpJs* titles. Adverbs, which may be termed as 'emotionally-charged words' like adjectives formulated in comparative and superlative forms, are much less common in the scientific titles than in the *SciAm* ones. The *SciAm* sample also contains contractions and phrasal verbs that reflect a more informal attitude:

Example 19: What's The Matter? (*SciAm*)

Example: 20: How To Blow Up A Star (*SciAm*)

Like contractions and phrasal verbs, a colloquial tone is obtained thanks to the Saxon genitive which is used to personify objects by attributing them human characteristics. This rhetorical device was registered only in two *SpJ*s titles (0.61%), whereas 12 *SciAm* titles (3.65%) included it:

Example 21: Theory of the Mercury's spin-orbit motion and analysis of its main librations (*SpJs*)

Example 22: Through Titan's Haze (*SciAm*)

According to Table 3 where the percentages for function words are displayed, prepositions topped the frequency scale of function words in scientific titles, followed by definite articles, conjunctions, indefinite articles, etc.

Table 3. Function words

Function words	*SpJs*	*SciAm*
Prepositions	580 (54.10%)	176 (38.77%)
Definite articles	252 (23.51%)	179 (39.43%)
Conjunctions	135 (12.59%)	20 (4.41%)
Indefinite articles	93 (8.68%)	42 (9.25%)
Possessives	4 (0.37%)	6 (1.32%)
Auxiliary verbs	3 (0.28%)	8 (1.76%)
Wh-words	3 (0.28%)	14 (3.08%)
Pronouns	2 (0.19%)	9 (1.98%)

The most frequent of the 22 recorded preposition variants was 'of' (45.36 % of all the prepositions) because of its wide range of uses within sentences. For instance, to say that something is attached to something or forms part of something; to specify or give more information about a particular process or action; to indicate a particular subject; to say that something has a particular characteristic or quality. The remaining preposition variants clustered around different frequencies, the least frequent ones being 'after', 'ahead of', 'among', 'as', 'onto', 'up to' and 'versus' (0.17 % each).

By contrast, definite articles were the most common type of function words in popular science titles although closely followed by prepositions. Then at a considerable distance stood indefinite articles, conjunctions, *wh*-words, pronouns, auxiliary verbs, and possessives. Within the 20 preposition variants registered in popular science titles, 'of' had once more the highest frequency of occurrence (40.90%), the lowest one corresponding to 'about', 'around', 'between', 'near', 'past', 'up to' and 'vs.' (0.57% each).

The coordinating conjunction 'and' was recorded in *SpJ*s titles on 134 occasions, whereas only 19 occurrences were found in *SciAm* titles. The coordinating conjunction 'or' was registered in only one popular science title. The higher frequency of occurrence of the coordinating conjunction 'and' and of the varied prepositions in scientific titles clearly accounts for their higher length, which is directly linked to higher informational content.

With respect to articles, in both samples the frequency of the definite article 'the' was much higher than that of the indefinite articles 'a' and 'an'. This could be interpreted as a desire to generalize the results obtained, although the possible drawbacks that generalizations usually imply would be somehow reduced by the presence of indefinite articles. On the other hand, the high number of definite and indefinite articles found in astrophysical titles does not seem to follow the recommendation given in style books according to which these articles should be avoided as much as possible because of the problems they tend to present for indexers (Langdon-Neuner, 2007).

'Its' and 'their' were the two possessives recorded in the scientific corpus, whereas the popular science sample contained three possessives: three titles with 'our', two titles with 'its' and one title with 'my'. The three auxiliaries recorded in scientific titles were 'does', 'is' and 'have' (one occurrence each). By contrast, popular science titles included eight auxiliaries: 'does', 'could' and 'is' were registered on two occasions each, and 'did' and 'would' were recorded on one occasion. The low number of auxiliaries is very likely related to the low number of question and verbal titles in both corpora, an issue that will be dealt with in the following section. The only three *wh*-words found in *SpJs* titles were ''how'', ''what'' and ''why'', "what" functioning as a pronoun, and "why" and ''how'' as subordinating conjunctions. On the contrary, 'how' and 'what' were present in ten *SciAm* titles (five each); 'when' was registered in two titles and 'why' and 'where' were found in one title each. The relative pronoun 'that' was retrieved on five occasions: two scientific titles and three popular science titles. Other pronouns that were also recorded in the popular science sample were the personal pronouns 'you' (two occurrences), 'it', 'they' and 'we' (one occurrence each). The greater use of possessives, auxiliaries, *wh*-words and personal pronouns in popular science titles are rhetorical strategies that allow the creation of a sort of dialogue and proximity between writers and readers.

Structural Variables

Table 4 discloses that the simple layout is the highest occurrence in both corpora.

Table 4. Structural variables

Structural variables	*SpJs*	*SciAm*
Simple	206 (62.61%)	322 (97.87%)
Compound	123 (37.39%)	7 (2.13%)
Nominal	319 (96.96%)	295 (89.67%)
Verbal	10 (3.04%)	34 (10.33%)
Interrogative	12 (3.65%)	17 (5.17%)
Exclamatory	0	2 (0.61%)

This result is not surprising since titles are strongly influenced by the constraints inherent in the economy of language and their primary function is to compress the maximum amount of information in the smallest possible space. However, compound constructions are much more common in scientific titles than in popular science ones, mainly because the former have to introduce specialized concepts in a more accurate and concise manner.

Colons, full stops and two-lines were mostly used to connect the different parts of *SpJs* compound titles. In the case of *SciAm* compound titles, colons were recorded on six occasions (see Example 6 and Example 28) and the only semi-colon present in our corpus was found in the following title:

Example 23: Inflation Is Dead; Long Live Inflation (*SciAm*)

Noteworthy is the absence of *SciAm* compound titles with full stops and written on two-lines. As for all the commas that were recorded in both samples, they were used either to enumerate things or to specify them, i.e. they did not mark any boundary between simple and compound titles:

Example 24: An attempt to probe the radio jet collimation regions in NGC 4278, NGC 4374 (M84), and NGC 6166 (*SpJs*)

Example 25: Black Stars, Not Holes (*SciAm*)

Sometimes the length and syntactic complexity proper of scientific compound titles is obtained by means of either a colon and a dash or two dashes in the same title:

Example 26: The Stagger-grid: A grid of 3D stellar atmosphere models - II. Horizontal and temporal averaging and spectral line formation (*SpJs*)

Example 27: The IACOB project − II. On the scatter of O-dwarf spectral type − effective temperature calibrations (*SpJs*)

Table 4 also shows that nominal structures were higher in scientific titles than in popular science ones. Conversely, verbal and interrogative constructions were less common (6.69%) in *SpJs* titles than in *SciAm* ones (15.50%), where a compound structure even contained a verb formulated in imperative form:

Example 28: Cloud to Black Hole: Eat My Dust (*SciAm*)

As for the exclamatory constructions, the two titles were only found in *SciAm* titles, one of them reading as follows:

Example 29: Saturnalia at last! (*SciAm*)

The low number of verbal titles in the scientific corpus clearly reflects the non-generalization of the results obtained in astrophysical research. This result corroborates Biber and Gray's (2010) statement that the combination of a highly specialized audience and a highly informational purpose implies a decreasing use of verbal structures. In this sense, it has to be taken into account that astrophysics is not a science that strictly follows the usual 'scientific method' of testing, hypothesis and refutation like, for example, biology or chemistry, where essays in laboratories allow investigators to repeat and modify the experimental conditions in order to obtain more reliable and trustworthy results. This is why cutting-edge findings in astrophysics tend to be approximate because the discipline mainly deals with distant objects that can be only seen through images or spectra. By contrast, generalizations in the popular science corpus are achieved not only through a higher number of verbal constructions, but also thanks to the definite article 'the'. Both rhetorical strategies may be connected to the need for a strong communicative imprint that resembles the journalistic style (Berkenrotter & Huckin, 1995).

Another rhetorical strategy used to help arouse readers' curiosity by connecting them to lived experience is the use of titles formulated as questions (e.g. Calsamiglia & Van Dijk, 2004; Fahnestock, 2004; Giannoni, 2008; Goodman, 2011; Hyland, 2010; Luzón Marco, 2013; Maisonneuve, Lorette, Maruani & Hughier, 2010; Soler, 2011). The lower presence of verbal constructions formulated as questions in *SpJs* also indicates that this structure is not usually favoured in scientific titles (e.g. Anthony, 2001; Busch-Lauer, 2000; Day, 1995; Hartley, 2007b; Gustavii, 2008; Langdon-Neuner, 2007; Lewison & Hartley, 2005; Maisonneuve, Lorette, Maruani, & Hughier, 2010; Soler, 2007, 2011; Wang & Bai, 2007).

CONCLUSION

Our analysis has put forward that scientific and popular science titles present a series of differences related to vocabulary and syntax. The higher number and of compound constructions in scientific titles clearly reflects their greater length when compared to popular science titles. All these characteristics go hand in hand with greater clearness, accuracy and preciseness, which allow academics decide on the relevance and usefulness of a given paper to their area of interest. Likewise, the greater use of qualifying adjectives and of technical terminology related to astrophysical matters (abbreviations, acronyms, eponyms, numbers, symbols, toponyms, and compound groups) suggest that scientific titles belong to specialized excerpts that are addressed to a more restricted audience than that of popular science titles.

In *SciAm* titles, by contrast, shorter titles are more creative and eye-catching and are aimed at hooking readers more easily. Adjectives, formulated in comparative and superlative forms, as well as exclamatory phrases and verbs formulated in imperative form, show emotional attitudes and strong feelings like excitement or surprise. Proper names, which mainly refer to well-known stars, planets, satellites and galaxies, imply on the one hand that *SciAm* audience has an educated level that is not entirely cut off from expertise and, on the other hand, that *SciAm* titles mainly deal with global and already established concepts. Personifying some objects through the use of the Saxon genitive relates these items to human beings with their emotions and innate curiosity. Addressing readers directly by means of personal pronouns and possessives enables to establish a closer relationship between senders and receivers. Like proper names, the higher use of verbal constructions and of the definite article in popular science titles when compared to scientific ones may be interpreted as a desire to generalize the ideas presented.

As happens with editorials and/oral communications, question titles arouse readers' curiosity and invite them to find an answer to the question asked in the title. It thus may be said that question titles directly involve the addressees of the message in a sort of dialogue that contributes to the expansion of their general knowledge. In the same vein as question titles, elements such as contractions and phrasal verbs also play an essential role in building a conversational tone.

Finally, it may be added that this is probably the first study devoted to the written encoding practices employed by researchers in the field of astrophysics when spreading their findings to different audiences, specialized and non-specialized. The analysis of a more comprehensive sample would probably yield more detailed insights in titling practices in astrophysics. It would also be interesting to carry out comparative studies of titles written in languages other than English in order to determine the most appropriate design of titles of scientific and popular science papers, not only in astrophysics but also in other fields.

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