The Role of Adverbs in Astrophysical Research Paper Abstracts

David I. Méndez [a, *], M. Ángeles Alcaraz [b]

[a] Department of Physics, System Engineering and Signal Theory, Polytechnic University College, University of Alicante, Spain
[b] Retired, Department of English Studies, Faculty of Arts, University of Alicante, Spain.
* Corresponding author Email: david.mendez@ua.es

Abstract: In this paper, we examine the presence of adverbs in 220 research paper abstracts published over an 11-year time span (2011–2021) in four top English-language journals in astrophysics, from both diachronic and cross-journal perspectives. Our main results reveal that, on average, adverbs account for about 3% of the total number of words, with adverbs ending in "-ly" making up approximately 40% of all adverbs and around 70% of their different variants. From a diachronic standpoint, the observed rising trend in the mean number of adverbs relative to the number of words, adjectives, main verbs, and authors may be attributed not only to the need for a thorough account of procedures and findings but also to the strategic management of discourse aimed at shaping editors' and readers' responses in an increasingly competitive scientific research environment. From a cross-journal perspective, the differences observed may be explained by a two-sided scenario: (1) abstracts published in journals with a more empirical and less generalist approach tend to contain more adverbs to provide a more detailed description of results and processes; (2) the use of adverbs by L2/L3 English authors varies from that of L1 English researchers, likely reflecting diverse proficiency levels in English. Our findings could benefit pedagogical studies in various fields by helping to bridge the gap between the written communication styles of L2/L3 and L1 English scientists, promoting clearer and more effective scientific discourse.

Keywords: Adverbs, Abstracts, Research Papers, Astrophysics, Diachronic, Cross-journal

1. Introduction

According to traditional grammars there are nine parts of speech (adjectives, adverbs, articles, conjunctions, interjections, nouns, prepositions, pronouns, and verbs) and any of them fulfil a certain function. For example, nouns are used to name something while adjectives modify or describe nouns, articles are noun equivalents and pronouns replace nouns. Conjunctions and prepositions, for their part, function as connectors, the former connecting words, phrases, clauses, or sentences, and the latter relating one word to another within a sentence. Interjections, which are rarely seen in formal writing, add meaning to a sentence or context by expressing a feeling, making a demand, or emphasizing a thought, whereas verbs convey actions, events, processes, states of being, thoughts, feelings and relationships. If we focus on adverbs, the online *Cambridge Dictionary* quotes that an adverb is a word that describes or gives more information about a verb, an adjective, a phrase, or another adverb. Very similar is the definition found in the online *Collins Dictionary* (an adverb is a word which adds information about the action, event, or situation mentioned in a clause). A little more specific is the description given in the online *Merriam-Webster Dictionary*, for which an adverb is a word belonging to one of the major form classes in any of numerous languages, typically serving as a modifier of a verb, an adjective, another adverb, a phrase, a clause, or a sentence, expressing some relation of manner or quality, place, time, degree, number, cause, opposition, affirmation, or denial, and in English also serving to connect and to express comment on clause content. Much alike is the explanation from the online *Oxford English Dictionary* (an adverb is a word or phrase that modifies or qualifies an adjective, verb, or another adverb or a word group, expressing a relation of place, time, circumstance, manner, cause, degree, etc.).

Apart from the definitions given in dictionaries, which help classify and understand the function and role of adverbs in written and spoken discourses, good guides for the teaching and learning of adverbs can be found in grammar books such as those by Aarts *et al.* (2014), Butterfield (2015), Heard (2022), Kaufman & Strauss (2021), among many others. Websites on English grammar rules, creative writing blogs and language forums are also available for L1 English students and L2/L3 English learners to use adverbs more effectively when reading, writing or speaking. Online Artificial Intelligence or Large Language Models English grammar checkers and writing assistants can be used for academic, technical and formal writing.

The important role played by adverbs in languages has thus provoked that different academic and theoretical frameworks of analysis and categorizations based on different criteria (grammatical, pragmatic, semantic, syntactic, etc.) have been proposed by well-known linguists such as, for instance, Quirk *et al.* (1985), Hudleston & Pullum (2002), Hyland (2005), Biber & Gray (2010), Halliday & Matthiessen (2014) or Downing (2014), to name but a few. These models of analysis have been the starting point for numerous studies carried out on adverbs from different perspectives and for varied purposes, mainly pedagogical. For example, in her thesis Heidler (2011) compares the use of adverbs between L2 English learners at intermediate and advanced levels and US-American college students in their published academic writings. Her main results reveal that although L2 English advanced students use adverbs in an accurate way, there are still some differences with their use by L1 English students.

Pérez-Paredes & Sánchez-Tornel (2014) examine the Polish, Spanish and Chinese components in the International Corpus of Cross-Linguistic Interlanguage to check how learners of English across different grades use general adverbs, especially those related to 'food' and 'money' topics. Their key findings report that both types of adverbs are more widely used as age increases. Tenuta *et al.* (2014) use the corpus of Brazilian Learners of English and the Louvain corpus of Native English Essays (LOCNESS) to investigate how Brazilian students express modality through adverbs in academic English. Their analysis discloses a given inflexibility in the L2 English written discourse as opposed to a more varied way in the L1 English speakers' data. Yilmaz & Dikilitaş (2017) analyse the use of English adverbs in written essays among Turkish students with a high level of English. They discover that 1) students prefer adverbs of degree to other adverbs, 2) they tend to overuse them, and 3) they use inappropriate adverbs.

Álvarez-Gil (2018) focuses on '-ly' adverbs in a corpus of English historic texts in Late Modern English and found that, apart from some disciplinary differences, the adverb 'fairly' functions as a mitigator in the vicinity of a modal verb, which may be considered an example of positive politeness to avoid any possible future academic criticism. Lewis (2019) examines the recent evolution of the adverb 'still' in terms of position, scope and sense and finds out that there is no evidence of any qualitative differences along time and that any possible shift is gradual and context-led. Wen & Lei (2022) carry out a diachronic study of adjectives and adverbs in articles published in the field of life sciences and observe an increase of their use that goes hand in hand with a decrease in readability of scientific texts.

Not only has the study of adverbs been discussed in written research in different languages and in various settings (as listed here-above) but also in spoken interactions, although to a lesser degree. In his comparative study (Swedish-English), Castello (2022) explores how stance adverbials in turn-initial and final positions, together with other linguistic elements, can contribute to discourse management in the L2 English field. Curry *et al.* (2022) investigate the adverbs used in casual spoken British English and share their findings with international English language editors in order to improve the contents of the course books they publish. Wang (2023) analyses adverbs in technology, entertainment and design scientific talks with a particular focus on the stance adverb 'really' in order to provide suggestions for public speaking in academic discourse.

If we refer to the presence of adverbs in abstracts, which is the gist of our investigation, Ahmad & Mehrjooseresht (2012) focus on stance adverbials in the English-written abstracts of doctoral theses by Malay students in the field of civil, electrical, mechanical and chemical engineering. Their results show that non-English writers use adverbials to mark their stance and comment on certainty and reliability of their research. Saunders (2013) looks for adverbs in 91,618 abstracts published in medical databases and discovers that 'finally' is by far the adverb most commonly used. Weinberger *et al.* (2015) collect a corpus of more than one million abstracts from eight disciplines over a 17 year-time span and establish a series of rules for writing in science. One of their findings is that scientists prefer longer abstracts with more adjectives and adverbs when using search engines, which leads to more bibliographic citations. Çakır (2016) explores how academic Turkish and L1 English writers from different scientific

communities (sociology, psychology, linguistics, physics, chemistry and biology) construct stance in research paper abstracts. The author discloses that English authors employ more stance adverbs than their Turkish counterparts and that more stance adverbs are used in soft sciences than in hard sciences. Finally, Bao (2022) compares stance adverbs in abstracts of doctoral dissertations written in English by Chinese and English-Americans doctors in the field of petroleum engineering. His main results show that both use epistemic stance adverbs with a similar frequency although the former prefer them to express affect. They also employ more boosters and hedges (subcategories of epistemic stance adverbs), which shows the influence of the English writing style.

2. Purpose, Corpus and Methodology

In this article we do not intend to provide any theoretical frameworks of analysis which have already been addressed on many occasions by renowned researchers, as already mentioned here-above. What we do expect is to contribute to the existing literature on adverbs by reporting the findings of a study of their presence in a corpus of research paper abstracts (from now on abbreviated as RPAs) published in astrophysics, a field not much explored from a linguistic point of view. In this sense, the present paper would complement our previous studies on RPAs in the same area of expertise (Méndez & Alcaraz, 2020; Méndez & Alcaraz, 2025a; Méndez & Alcaraz, 2025b).

Before going on, we would like to point out that in our analysis we have adopted the basic definitions of adverbs given in the online versions of the *Collins* and *Cambridge* dictionaries, i.e. words that give more information about a verb, an adjective, a phrase, or another adverb.

Towards this end, we explored the presence of adverbs in a corpus of English-written RPAs retrieved from the principal scholarly journals published in the field of Astrophysics. There have been several reasons for choosing this topic. First, we have chosen astrophysics because it has seldom been approached from a linguistic point of view, probably because astrophysics (a mixture of astronomy and physics) and linguistics are two distant areas of expertise that have rarely led to joint venture. If, on the one hand, the majority of astrophysicists show little concern for linguistic matters, on the other hand, most linguists are not aware of astronomical and physical issues. In other words, the lack of shared knowledge on the part of both communities has prevented a fruitful partnership which is essential for this type of research. Second, the main advances in astrophysics are published in journals written in English, the most prestigious ones being *Astronomy & Astrophysics* (A&A), *Astronomical Journal* (AJ), *Astrophysical Journal* (ApJ) and *Monthly Notices of the Royal Astronomical Society* (MNRAS). This is the reason why we have selected the referred journals to collect our corpus of analysis. Third, we have analysed RPAs because they provide the best summaries for researchers when it comes to decide the articles that interest them more, both for their continuous training and for the dissemination of new knowledge within the academic and scientific community all over the world. Fourth, adverbs are necessary to strengthen theoretical, observational and instrumental descriptions that are the core of astrophysics.

Since our research is a multi-faceted one, we asked ourselves the following questions:

1) What is the proportion of adverbs in relationship with the total number of words?

2) What is the total number of adverbs with regards to the total number of adjectives and main verbs?

3) What are the adverbs with the highest frequency of appearance?

4) What is the number of '-ly' adverbs in comparison with the rest of adverbs and what are the most frequent '-ly' adverbs?

5) What is the total number of adverbs with regards to the total number of authors?

6) From a cross-journal standpoint, are there any differences with respect to the use of the studied items?

7) From a diachronic point of view, are there any variations regarding all the referred points?

As previously done in our former papers on RPAs (Méndez & Alcaraz, 2025a; 2025b), we gathered our corpus from the accessible online version of the four aforementioned English-written international journals, namely A&A, AJ, ApJ and MNRAS.

A&A, an originally European-based journal distributed on behalf of the European Southern Observatory, currently belongs to China Science Publishing & Media and publishes papers on theoretical, observational and instrumental astronomy and astrophysics. AJ primarily deals with astronomical issues while ApJ has a more theoretical and generalist trend and discusses matters related to astronomy and astrophysics. Both AJ and ApJ are US-based and are published in the name of the American Astronomical Society. Finally, MNRAS, which is often preferred by astronomers from the United Kingdom and the Commonwealth, covers research on astronomy and astrophysics and is published on behalf of the Royal Astronomical Society.

Our research is based on a self-built corpus composed of 220 RPAs recorded in a period of 11 years (2011-2021), with a total number of 57,972 running words. Although our sample may seem relatively small, we believe that, in line with authors such as Banks (2005), Belcher (2005), Flowerdew (2005), or Nesi (2013), to name just a few, its analysis can yield results worth taking into account.

Due to the counting methodology adopted in our study, i.e. word by word, we have only registered and analysed single word adverbs. Multi-word adverbs like 'for example', 'for instance', 'in addition', 'in summary', 'in conclusion', 'in spite of', 'on the other hand', or 'of course' were excluded from our analysis. Anyway, the rate of occurrence of these multi-word adverbs is very low as neither of them were found either in AJ or MNRAS RPAs although 'in addition' appeared in three ApJ RPAs (June and September 2014, and October 2021) and 'for example' only occurred once in A&A RPAs (October 2021). The scarcity of this type of adverbs may be due to the abstract word limit advised by the majority of journal guidelines.

Once our corpus collected, we counted the total number of words included in each RPA. The task was not easy because in some RPAs we found different types of words: groups of words separated by blank spaces or hyphens, complex expressions including words, numbers, chemical and/or mathematical symbols, and abbreviations. This is the reason why we had to count our corpus of adverbs manually because the computerised programmes generally used to retrieve linguistic information would have not helped us achieve our purpose.

So the expression 'Gas-rich late-stage dwarf-dwarf merger' (ApJ, September 2020), which may be termed as a "compound group", was counted as seven words. In the case of compound groups, it is worth noting that sometimes their components may be written either separated by a blank space or linked by a hyphen depending on the authors' preference or style. This would be the case of the compound noun 'surface gravity' (AJ, December 2012), which may also appear with a dash ('surface-gravity', AJ, March 2019).

Initialisms (abbreviations formed from the initial letters of constituent words and pronounced separately) were recorded according to their individual semantic components. For instance, 'CMP' *(< Cosmological Model Parameter)* (MNRAS, December 2021) was counted as three distinct words. In contrast, acronyms (letter sequences exhibiting a syllabic structure and typically pronounced as a single word) such as 'MOSFIRE' (< Multi-Object Spectrometer For Infra-Red Exploration) (MNRAS, November 2021) were treated as single lexical items. Symbols representing chemical elements, composed of one or two letters, were likewise considered as single words. A more complex expression incorporating nouns, a past participle, an initialism and numerical elements was recorded as eight words:

"gas-dominated merger remnant VCC 848" ('VCC' < Virgo Cluster Catalogue) (ApJ, September 2020).

Then we computed several extrinsic variables (total numbers of adverbs, adjectives and verbs, and authors) and intrinsic variables (mean number of adverbs per number of words, verbs, adjectives, adjectives and verbs, and authors. Finally, to complement our quantitative analysis and to determine whether the differences observed in the referred numerical variables were statistically significant or not, we submitted our data to the parametric Student's t-test. The alpha value was set at 0.05. That is, we combined both manual and computerised analyses.

An important fact that we would like to insist upon is that our corpus of adverbs includes particles that may fit into other parts of speech as long as they grammatically function as adverbs. This would be the case of the graphic forms 'out', 'up' and "likely", as exemplified here-below:

1) "Our model favours attributing the two high-frequency QPOs, often occurring in a near 3:2 frequency ratio, to the breathing and vertical epicyclic frequency modes of the hot, thick flow, although we cannot rule *out* the Keplerian and $m = -1$ radial epicyclic modes." (MNRAS, September 2016)

2) "The physical structure of hot molecular cores, where forming massive stars have heated *up* dense dust and gas, but have not yet ionized the molecules, poses a prominent challenge in the research of high-mass star formation and astrochemistry." (A&A, December 2011).

3) "That time delays in lensed quasars are themselves time variable *likely* explains why repeated delay measurements of individual lensed quasars appear to vary by more than their estimated uncertainties." (MNRAS, November 2018)

3. Results and Discussion

3.1. Cross-journal analysis

Table 1 displays a cross-journal analysis of the approached extrinsic variables.

Table 1. Extrinsic variables

Journal	Number of words	Number of adverbs	Number of verbs	Number of adjectives	Number of authors
A&A	17,076	545	1,539	3,067	443
ApJ	14,341	392	1,146	2,756	845
MNRAS	13,517	388	1,189	2,591	347
AJ	13,038	435	1,082	2,490	463
TOTAL	57,972	1,760	4,956	10,904	2,098

As can be seen, 1,760 adverbs were recorded in the whole sample, which amounts to about a 3% of the total number of words. The highest number of adverbs is found in A&A (30.97%), a journal which publishes papers dealing with experimental/theoretical matters. AJ, with a tendency to more experimental topics, comes in the second place as far as the number of adverbs is concerned (24.72%), whereas ApJ and MNRAS, which report contrasted final results and are therefore the least experimental of the four analysed journals, contain the lowest numbers of adverbs (22.27% and 22.04%, respectively).

The results of a more in-depth analysis related to the adverbs variants (including '-ly' adverbs) are depicted in table 2 (we decided to address adverbs ended in '-ly' since this suffix is a common way to form adjectives and adverbs in English).

Table 2. Adverb variants

Journal	Adverb variants	'-ly' adverbs	'-ly' adverb variants	'-ly' adverb percentages
A&A	150	189	91	34.67%
ApJ	156	175	103	44.64%
MNRAS	144	159	88	40.61%
AJ	156	172	91	39.54%
TOTAL	298	695	205	39.45%

ApJ and AJ RPAs include the highest numbers of adverb variants (156 each). Moreover, ApJ RPAs contain the highest number of '-ly' variants (103 and almost 45%) and MNRAS RPAs the lowest one (88 and 40.61%), although the lowest percentage of '-ly' variants corresponds to A&A RPAs (34.67%). Table 2 also reveals that in comparison to the total of 1,760 adverbs (Table 1), the number of adverbs ended in '-ly' (695) only amounts to 39.45%. On the contrary, if we compare the 205 '-ly' variants with the 298 variants of all the registered adverbs, we can see that they reach almost 69%. Furthermore, the fact that the highest number and percentage of '-ly' variants are found in ApJ RPAs, a generalist journal owned by the US-American Astronomical Society, would not fully conform to the statement by the online *Merriam-Webster Dictionary* that "most adverbs are formed by adding '-ly' to an adjective" since they would only apply to the '-ly' variants, but not to the total number of adverbs ended in '-ly'. Our results would thus demonstrate that although adverbs ended in '-ly' are often cited as examples to demonstrate how adverbs work, astrophysicists prefer not to use them much perhaps due to their possible overlapping with adjectives with the same graphic form.

Table 3 illustrates the top ten adverbs found in the whole corpus.

Table 3. Adverbs with a higher number of appearances

Adverb	Number of appearances	Percentage (%)
Also	96	5.45
Not	89	5.06
Very	70	3.98
Well	67	3.81
More	64	3.64
However	54	3.07
Only	43	2.44
Most	36	2.05
Likely	35	1.99
Out	35	1.99

As can be appreciated, 'also' is the most productive adverb found in our sample, closely followed by 'not'. 'Very', 'well', 'more' and 'however' show percentages higher than 3%. 'Only' and 'most' present percentages higher than 2% while 'likely' and 'out' almost reach 2%.

The prevalence of 'also' was also found by Heidler (2011) in her analysis, whereas it ranked third, followed by 'only', in the studies by Pérez-Paredes & Sánchez-Tornel (2014) and Álvarez-Gil (2018). On the contrary, 'only' is our seventh most common adverb and 'very' comes in the third place of the scale, although it occupies the first one in Yilmaz & Dikilitaş (2017)' research. As Lewis (2019) states, the observed variations are probably due to the different contexts analysed (field of knowledge, sample, period, etc.).

The fact that 'very' is the third most frequently used adverb in our corpus (nearly 4%) slightly differs from the advice by *Enago Academy* (2018) that intensive adverbs such as 'very' and 'extremely' should be avoided in academic writing because "they often weaken the words they describe". This quote would exemplify the sparing uses of adverbs supported by well-known novelists such as Green, Hemingway, King, Twain, etc. (Donovan, 2019). Non-fiction writers (Zinsser, 2006; Okulicz-Kozaryn, 2013; Wen & Lei, 2022; etc.) also recommend to employ adverbs only when necessary, as does the vast majority of online writing tips, editing apps and large language models based on artificial intelligence designed to improve the quality of academic, scientific and technical writing. However, what is advised and what is done do not always go hand in hand, mainly in scientific writing, where adverbs are necessary to specify the experiments carried out and the results obtained (Saunders, 2013; Weinberger *et al.*, 2015; Hervé This, 2023).

Table 4 outlines the '-ly' adverbs most frequently used in our sample.

Table 4. '-ly' adverbs with a higher number of appearances

Adverb	Number of appearances	Percentage (%)
Likely	35	1.99
Previously	26	1.47
Finally	23	1.31
Respectively	21	1.19
Significantly	18	1.02
Recently	15	0.85
Approximately	14	0.80
Relatively	14	0.80
Directly	13	0.74
Extremely	13	0.74
Spatially	13	0.74

Since 'likely' is the only '-ly' adverb that figures in Table 3, which lists the ten most commonly used adverbs in the whole sample, it is not surprising that 'likely' (1.99%) occupies the first place in Table 4. In addition, Table 4 states that the second '-ly' adverb in frequency is 'previously' (1.47%), closely followed by 'finally' (1.31%), which is the most common adverb found by Saunders (2013).

Of the six remaining adverbs ended in '-ly', 'significantly' is the only one showing a percentage higher than 1%. By the way, 'extremely' also appears in Table 4, although its low frequency of appearance suggests that its use follows the recommendation by *Enago Academy* (see explanations regarding Table 3).

From a cross-journal standpoint, 'also' is again the most common adverb found in A&A, AJ and MNRAS RPAs (5.67%, 5.98% and 5.67%, respectively). 'Also' ranks fourth in ApJ (4.34%), 'very', 'not' and 'well' being above it (5.87%, 5.61% and 4.59%, respectively). As for '-ly' adverbs, 'likely' occupies the first place in AJ, ApJ and MNRAS RPAs (2.30%, 2.30% and 1.80% each), whereas it ranks second in A&A RPAs (1.65%), the first place corresponding to 'finally' (2.02%). The prevalence of 'finally' over 'likely' in A&A RPAs is probably due to their structured format into different paragraphs (Méndez & Alcaraz, 2025a; 2025b).

Although syntax issues were not at first included in the objectives of our study, we considered that dedicating a few lines to this topic would enrich our research. The first thing that stands out in our corpus is that adverbs are characterized by their mobility, i.e. they can occupy different positions in the sentence: initial, medial and final. If we have a look at the adverbs with a frequency of occurrence above 3% (Table 3), we can say that 'also' usually precedes conjugated verbs and when it appears in compound tenses it is used between the auxiliary verbs and the past participles. Only on one occasion did we find it at the beginning of a sentence followed by a comma. In this case, it can be said that the front position occupied by the adverb emphasizes the whole sentence that follows or adds a new point of topic. 'Not' is the most typical adverb of negation and usually appears in negative forms after the auxiliary verb 'do' or after modal verbs. 'Very' is mostly followed by an adjective and sometimes it modifies another adverb. 'Well' usually describes past participles in passive forms and on one occasion we found it after a comma in final position preceded by 'as', i.e. acting as a synonym of 'also' or 'too'. 'More' always qualifies adjectives, whereas 'however' mostly appears at the beginning of a clause before a comma, although sometimes it is found mid-sentence between commas or after a semi-colon and followed by a comma. In the first case it acts as a 'sentence adverb', as does 'also' in the same position. In the remaining cases the adverb is used to connect two independent clauses and to show a close relationship between them.

With regards to adverbs with a frequency of appearance below 3%, 'only' is mainly followed by adjectives and to a lesser extent by adverbs. We also found it once at the end of a sentence. Thus it could be said that it is used to give extra emphasis to the sentence it applies to, as does 'also' in front position. 'Most' appears in pre-adjectival positions while 'likely' is placed after a verb, before a verb (in passive forms) and before another adverb. As for 'out', in most cases it is used after the verb 'rule' and its low frequency of appearance is in line with Knapen *et al.* (2022) who claim that phrasal verbs should be avoided in Formal English, which is the language used in written academic and scientific documents.

If we focus on the placement of '-ly' adverbs within the sentences where they are found, we can say that 'previously' usually qualifies a past participle and is either placed before or after it, whereas 'finally' and 'recently' are used at the beginning of sentences followed by commas. In this case, it may be said that they apply to whole sentences and are 'sentence adverbs', like 'however' and 'also' referred here-above. 'Respectively' may be also be considered a sentence adverb when it appears at the end of sentences or after a comma, although on some occasions it is found mid-clause between commas. 'Significantly', 'extremely' and 'spatially' describe adjectives and past participles while 'approximately' and 'relatively' modify either an adjective or a verb and 'directly' is applied to verbs. The adverb sentence mobility observed in our corpus would somehow differ from Knapen *et al.* (2022), although it has to be taken into account that we have analysed abstracts and not whole articles as they did.

Dealing now with intrinsic variables, Figure 1 plots a cross-journal analysis of the mean number of adverbs per number of words.

The highest presence of adverbs with respect to the number of words is reached in AJ (0.033) while the lowest one corresponds to ApJ (0.028), the difference between them being statistically significant (p=0.025). The value for A&A closely corresponds to AJ while MNRAS resembles ApJ. Adverbs are most frequent in the more experimental AJ, and least frequent in the more generalist ApJ and MNRAS. This should come as no surprise since the more experimental a journal is the more specific it must be and adverbs are useful tools to give more comprehensive information. As for A&A, the high number of adverbs per number of words could be understood in light of the demographic of A&A authors, who are generally L2/L3 English researchers, often from non-European backgrounds. This aligns with the expanding body of work contributed by L2/L3 English writers globally. Furthermore,

our absolute results for the mean number of adverbs per number of words clearly overcome the ones obtained by Heidler (2011), although it has to be taken into account that her analysis neither includes astrophysics nor RPAs but compares the writing of L2 English speakers at an intermediate and advanced level to both US-American college students' writing and published academic writing.
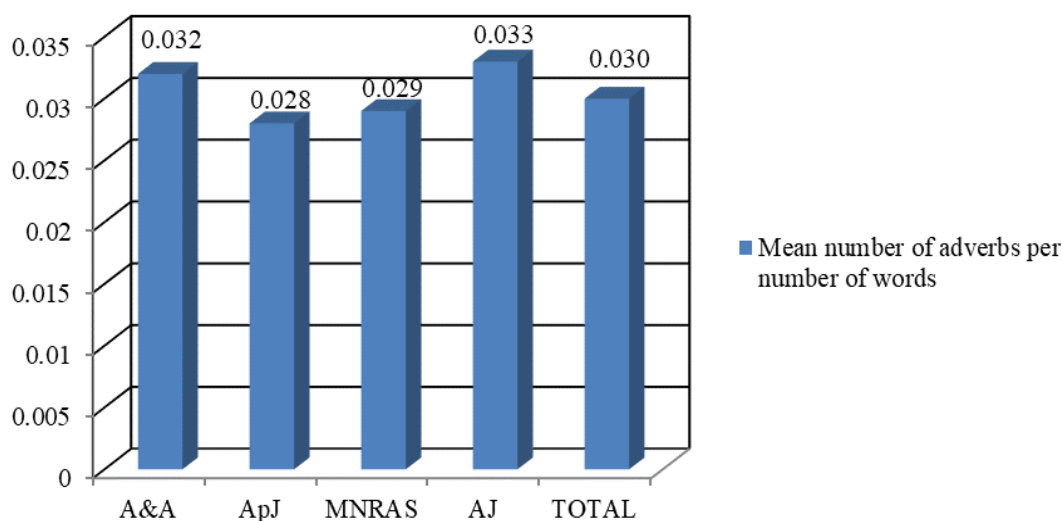

Figure 1. Mean number of adverbs per number of words

Figure 2 shows a cross-journal analysis of the mean number of adverbs per number of verbs, adjectives, and verbs and adjectives.
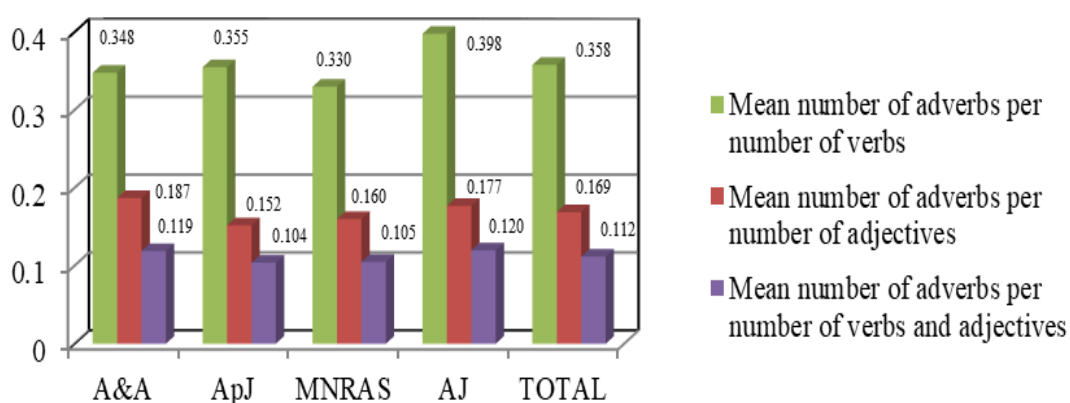
Figure 2. Mean number of adverbs per mean number of verbs, adjectives, and verbs and adjectives

With regards to the mean number of adverbs per number of verbs, the highest value corresponds to AJ (0.398) and the lowest one to MNRAS (0.330), the difference between them being statistically significant (p=0.024). A&A and ApJ show intermediate values between AJ and MNRAS, although they are clearly closer to the MNRAS ones, but with no statistically significant differences. The highest value revealed by AJ would prove once again its more experimental scope as more adverbs are needed to describe verbs in a more precise way. It could be argued that descriptive verbs could be used instead but it has to be taken into account that the main aim for scientists is to communicate results and spending much time looking for the most appropriate words does not usually fit into their primary objectives. Moreover, if we bear in mind that ApJ has the lowest mean numbers of verbs per number of words (Méndez & Alcaraz, 2025b), it is not surprising that it exhibits the second highest value for the mean number of adverbs per number of verbs. In addition, although A&A show a higher mean number of verbs per number of words with respect to MNRAS, the lower mean number of adverbs per number of verbs found in MNRAS with respect to A&A would stand for an L2/L3 English scenario in the case of A&A.

As for the mean number of adverbs per mean number of adjectives, the highest value corresponds to A&A (0.187) and the lowest one to ApJ (0.152), the difference between them being statistically significant (p=0.015). The differences between A&A and AJ (0.177) and MNRAS (0.169) are also statistically significant (p=0.042 and p=0.046, respectively). The highest value of the mean number of adverbs per number of adjectives found in A&A could be due to the fact that this journal displays the lowest mean number of adjectives per number of words (Méndez & Alcaraz, 2025a). Since AJ is the journal with the highest mean number of adjectives per number of words, its second highest value for the mean number of adverbs per number of adjectives may show again its more experimental approach, i.e. many adverbs and adjectives are needed to describe research in full details. As for MNRAS and ApJ, if we consider that their mean numbers of adjectives per number of words are considerably high (Méndez & Alcaraz, 2025a), their lower mean numbers of adverbs per number of adjectives with respect to A&A and AJ could be interpreted in terms of their more generalist scope. All in all, the low values found for the mean number of adverbs per number of adjectives are in agreement with the claim by Yilmaz & Dikilitaş (2017) that while adjectives are regularly needed to define nouns in propositions and whose absence can produce ambiguity, adverbs are generally optional. However, this statement should be somewhat softened from a more empirical approach.

Finally, AJ (0.120) and ApJ (0.104) show, respectively, the highest and lowest values of the mean number of adverbs per number of adjectives and verbs, the resulting difference being the only statistically significant one (p=0.040) among the four journals. The A&A value is closer to the AJ one while that of MNRAS approaches that of ApJ. Once more, these findings may be discussed in terms of experimental/generalist scopes or L1/L2/L3 English scenarios.

Figure 3 displays a cross-journal study of the mean number of adverbs per number of authors.
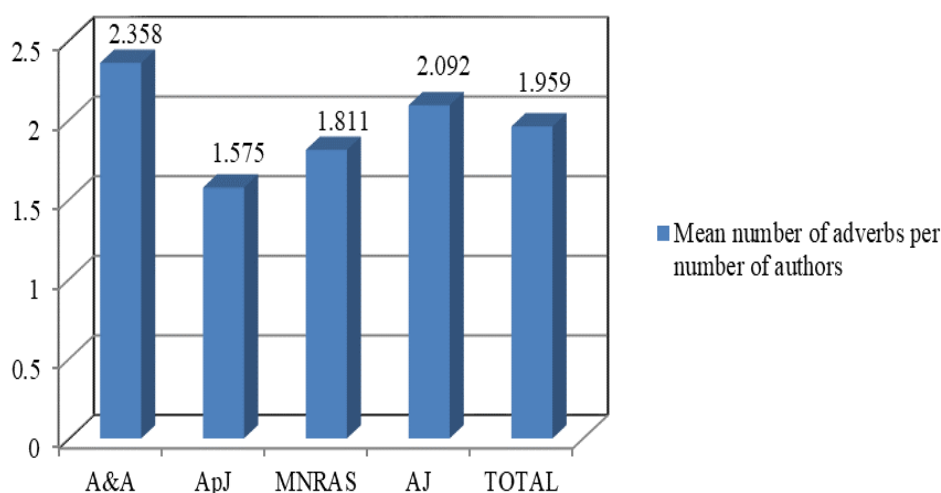

Figure 3. Mean number of adverbs per number of authors

As depicted in Figure 3, A&A (2.358) and AJ (2.092) show values greater than 2 for this parameter while the minimum value corresponds to ApJ (1.575), the journal with the highest number of authors (Table 1). Statistically significant differences can only be found between A&A and ApJ (p=0.041). The mean number of adverbs per number of authors exhibits the same pattern as the mean number of adverbs per number of words (Figure 1), and the mean number of verbs per number of words and authors, but for the higher values found in MNRAS (Méndez & Alcaraz, 2025b). These results may be explained if we consider that authors that publish in MNRAS are primarily L1 English, i.e. they generally tend to use more appropriate verbs and so need fewer adverbs to clearly express their results and ideas (Ruan, 2018; Xue & Ge, 2021).

From a cross-journal point of view, it may be then concluded that, in average, authors who have an L1 English background tend to use fewer adverbs in the RPAs published in journals with a less empirical and more generalist approach.

3.2. Diachronic study

Figure 4 exhibits the evolution over time of the mean number of adverbs per number of words in the whole sample.
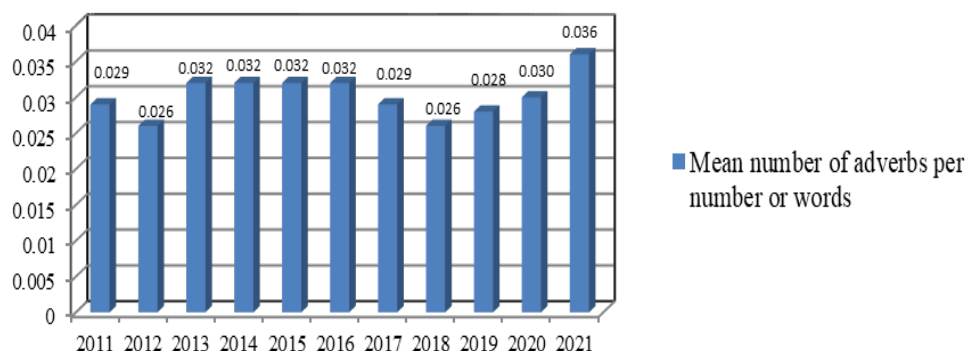

Figure 4. Evolution over time of the mean number of adverbs per number of words

Although there exists an erratic behaviour in the time span under study, an overall increase can be clearly seen between 2011 and 2021 (from 0.029 in 2011 to 0.036 in 2021, p=0.039). The growth is even more noticeable between 2012 (0.026) and 2021 (0.036) with a higher statistical significance (p=0.012). The lowest values of this variable are reached in 2012 and 2018, the difference between 2018 and 2021 being also more significant (p=0.017) than the one corresponding to the period 2011-2021.

Figure 5 presents the evolution over time of the mean number of adverbs per number of verbs, adjectives, and verbs and adjectives.
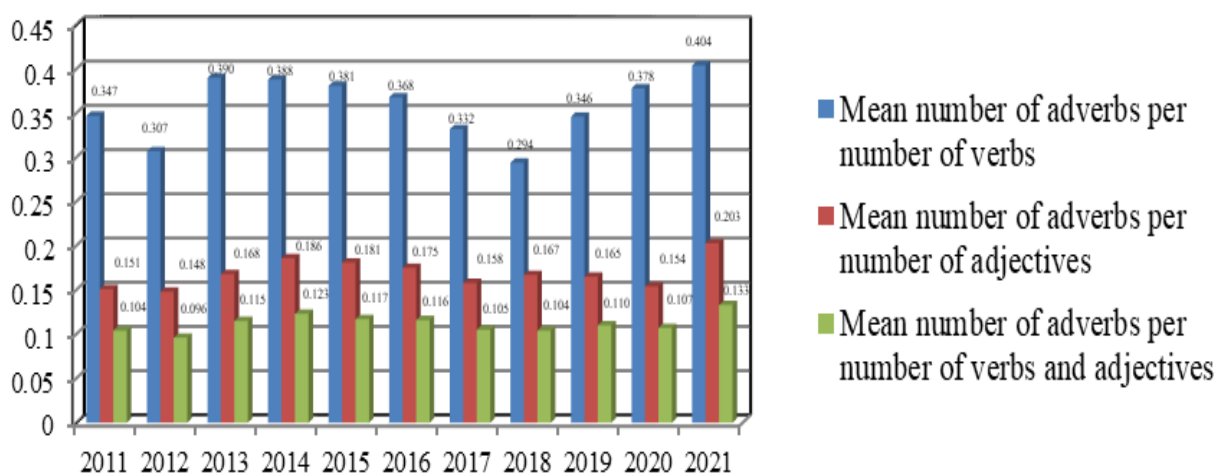

Figure 5. Evolution over time of the mean number of adverbs per number of verbs, adjectives, and verbs and adjectives

Considering our counting methodology and the fact that verbs and adjectives are more numerous than adverbs themselves (clearly stated by the fact that all variables in Figure 2 are smaller than 1), it should come as no surprise that the erratic pattern already observed in Figure 4 occurs once more in Figure 5.

As can been seen, the mean number of adverbs per number of verbs exhibits a parallel pattern to the one observed in the mean number of adverbs per number of words (Figure 4). There also exists an overall increase between 2011 and 2021 but the difference is only statistically significant (p=0.011) between 2012 (0.307) and 2021 (0.404). Likewise, we find a significant growth (p=0.015) between 2018, once again the year with the lowest value (0.294), and 2021. Contrary to the behaviour noticed in the mean number of adverbs per number of verbs, where the year 2018 shows the minimum value, there is a statistically significant upward trend (p=0.026) in the mean number of adverbs per number of adjectives between 2011 (0.151) and 2021 (0.203). We also detect an overall statistically significant rise (p=0.025) in this variable between 2012, the year with the lowest value (0.148), and

2021. As for the mean number of adverbs per number of verbs and adjectives, an overall statistically significant growth (p=0.032) is seen between 2011 (0.151) and 2021 (0.203). Besides, we find a decrease in 2018 (0.104) but the lowest value of this last variable is reached in 2012 (0.096), the differences between both years and 2021 being once more statistically significant (p=0.010 between 2012 and 2021 and p=0.041 between 2018 and 2021).

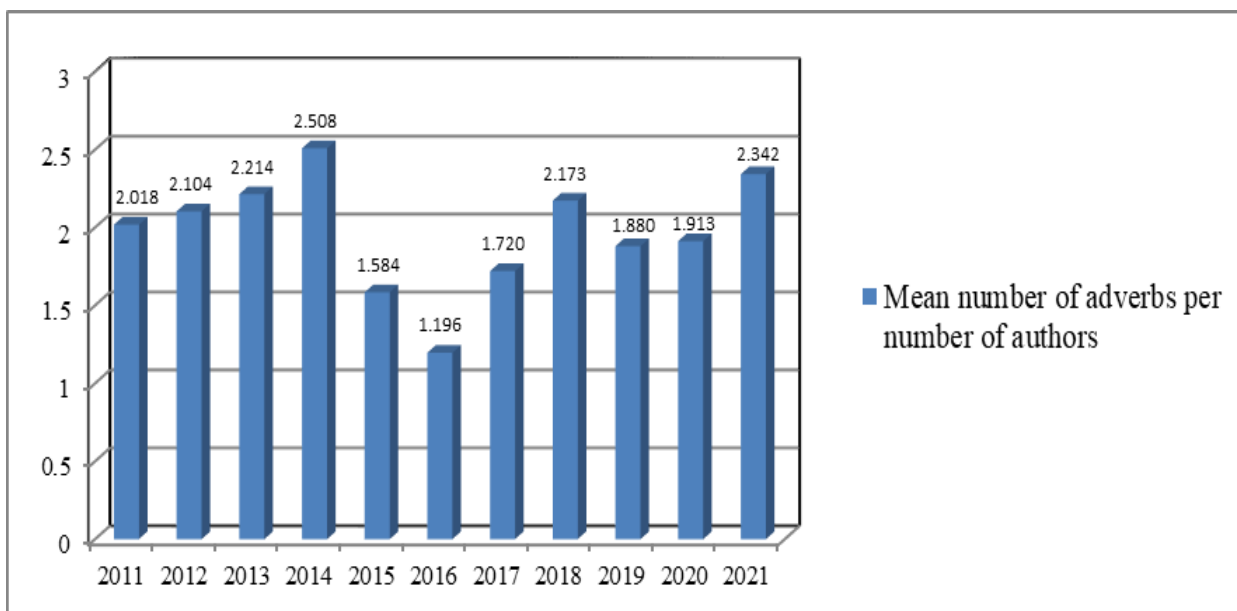Figure 6 shows the evolution over time of the mean number of adverbs per number of authors.

Figure 6. Evolution over time of the mean number of adverbs per number of authors

As illustrated in Figure 6, the peak is marked in the year 2014 (2.508) against the year 2016 (1.196) although the difference is barely statistically significant (p=0.053). Nevertheless, statistically significant differences are found between 2013 (2.214) and 2016 (p=0.037) and 2016 and 2021 (2.342) (p=0.031) despite some downs in 2019 (1.880) and 2020 (1.913). All in all, it seems that authors tend to use more adverbs, which is clearly noticeable since 2016.

The growing use of adverbs and adjectives would thus corroborate the results by Wen & Lei (2022) in their study on adjectives and adverbs. Moreover, it could be argued that the upward trend noticed in all the variables analysed is due to the need for a more accurate account of the results obtained and the processes executed. Nevertheless, it may also be possible to attribute this behaviour to a somewhat rhetoric "manipulation" together with a more literary-oriented purpose (Baskin, 2022; Dodonov, 2022; Mello, 2022) so as to get approval with research from journals' editors and to reach a wider audience. That way, authors would achieve greater visibility within their community, an important issue in today's competitive scientific research world.

The shifts noticed must be, however, taken with caution because of the reduced time-span analysed. As Guillaerts (2014) and Lewis (2019) claim, only over long time periods is it possible to appreciate a clearer evolution in the use of adverbs. Our small sample size may also introduce some limitations when interpreting and generalizing results.

4. Conclusions

In this paper we have carried out both synchronic and diachronic analyses of the role of adverbs in a corpus of 220 RPAs published in the four most prestigious English-written astrophysical journals. Our main results may be summarized as follows:

1) In average, adverbs account for about a 3% of the total number of words, '-ly' adverbs amounting to approximately 40% of the total number of adverbs.

2) Of all the different adverb variants found, around 70% corresponds to '-ly' adverbs.

3) The two variants with percentages greater than 5% are 'also' and 'not', whereas 'likely', the most productive of '-ly' adverbs, appears in the ninth position of the most common adverbs with a percentage near 2%.

4) From a cross-journal standpoint, the highest presence of adverbs with respect to the number of words is reached in AJ while the lowest one corresponds to ApJ. A&A and AJ show similar values as opposed to MNRAS and ApJ, which display comparable indicators.

5) With regards to the mean number of adverbs per number of verbs, the highest value corresponds to AJ and the lowest one to MNRAS. A&A and ApJ show intermediate figures in the scale, although they are clearly closer to MNRAS.

6) In the case of the mean number of adverbs per mean number of adjectives, the highest value corresponds to A&A and the lowest one to ApJ, AJ being closer to A&A and MNRAS to ApJ.

7) AJ and ApJ show the highest and lowest values of the mean number of adverbs per number of verbs and adjectives. The A&A value is closer to AJ and that of MNRAS to ApJ.

8) The mean number of adverbs per number of authors exhibits the same cross-journal pattern as the mean number of adverbs per number of words (point 4).

9) All the previous findings may be explained within a two-sided scenario: on the one hand, a more empirical and less generalist approach, where more adverbs are needed in order to present results and processes in more detail, and, on the other hand, an L2/L3 English author context with varying levels of English language proficiency.

10) Diachronically speaking, the rising trend noticed in all the variables analysed may also be interpreted from two different standpoints: 1) the need for a more exhaustive description of the procedures followed and the findings achieved and 2) a sort of discourse handling in order to shape editors' and readers' response.

In other words, the use of adverbs detected in astrophysical RPAs is conditioned not only by the sphere of each journal (experimental versus generalist) but also by the origin of the publishing authors, i.e. L1 English writers versus L2/L3 English authors. To enhance clarity and precision, L2/L3 English researchers should try to align their vocabulary choices with those of L1 English researchers, particularly regarding verbs, adjectives, or phrases that inherently convey the meaning of their modifiers. In this regard, pedagogically-focused studies across various disciplines would prove highly valuable.

In any case, and although adverbs have been objected to in numerous usage guides and by many known writers –"The road to hell is paved with adverbs", wrote Stephen King in his *Onwriting: A memoir of the Craft* (2000)–, we think that it is a matter of balance, i.e. use adverbs when they are needed and avoid them when they are not. As Anton Chekhov (1899) said to Maxim Gorky, "when you read proof, take out adjectives and adverbs wherever you can". And we would add, mainly in abstracts which are concise summaries that must condense the maximum amount of data into the minimum number of words.

References

Aarts, B., Chalker, S., Weiner, E. (2014). Oxford Dictionary of English Grammar. *Oxford University Press*, Oxford.

Ahmad, U., Mehrjooseresht, M. (2012). Stance adverbials in engineering thesis abstracts. *Procedia - Social and Behavioral Sciences,* 66, 29-36. https://doi.org/10.1016/j.sbspro.2012.11.244

Álvarez-Gil, F.J. (2018). Adverbs ending in -ly in Late Modern English. *Evidence from the Coruña Corpus of History English Texts. Estudios de Lingüística Aplicada, 4. Universitat Politécnica de Valencia*, Valencia.

Banks, D. (2005). The Case of Perrin and Thompson: An example of the use of a mini corpus. *English for Specific Purposes,* 24(2), 201-213. https://doi.org/10.1016/j.esp.2004.01.001

Bao, J. (2022). A Comparative study on stance adverbs in abstracts of doctoral dissertations by Chinese and Americans. A Case study in petroleum engineering. *International Journal of Language and Linguistics,* 10(2), 95-102. https://doi.org/10.11648/j.ijll.20221002.15

Baskin, T. (2022). No, adverbs aren't ruining our scientific literature. *Scientist Sees Squirrel*. https://scientistseessquirrel.wordpress.com/2022/09/13/no-adverbs-arent-ruining-our-scientific-literature/

Belcher, D. (2005). Editorial. *English for Specific Purposes,* 14, 119-121. https://doi.org/10.1016/j.esp.2004.11.002

Biber, D., Gray, B. (2010). Challenging stereotypes about academic writing: Complexity, elaboration, explicitness. *Journal of English for Academic Purposes,* 9(1), 2-20. https://doi.org/10.1016/j.jeap.2010.01.001

Butterfield, J., (2015). Fowler's dictionary of Modern English usage. *Oxford University Press*, Oxford. https://doi.org/10.1093/acref/9780199661350.001.0001

Çakır, H. (2016). Native and non-native writers' use of stance adverbs in English research article abstracts. *Open Journal of Modern Linguistics*, 6(2), 85-96.

Cambridge Dictionary (n.d.) *Adverb*. https://dictionary.cambridge.org/dictionary/english/adverb

Castello, E. (2022). Stance adverbials in spoken English interactions: Insights from corpora of L1 and L2 elicited conversations. *Contrastive Pragmatics*, 4(1), 1-31. https://doi.org/10.1163/26660393-bja10065

Collins Dictionary (n.d.) Adverb. In collinsdictionary.com.

Chekhov, A. (1984). The selected letters of Anton Chekhov. *Macmillan*.

Curry, N., Love, R., Goodman, O. (2022). Adverbs on the move: Investigating publisher application of corpus research on recent language change to ELT coursebook development. *Corpora*, 17(1), 1-38. https://doi.org/10.3366/cor.2022.0233

Dodonov, P. (2022). No, adverbs aren't ruining our scientific literature. *Scientist Sees Squirrel.*

Donovan, M. (2019). Ready, set, write: A guide to creative writing. *Swan Hatch Press.*

Downing, A. (2014). English Grammar: A university course. *Routledge*, London. https://doi.org/10.4324/9781315750040

Enago Academy (2018). How to use adverbs effectively in journal manuscripts. *Enago Academy.* https://www.enago.com/academy/how-to-use-adverbs-effectively-in-journal-manuscripts/

Flowerdew, L. (2005). An integration of corpus-based and genre-based approach to text analysis in EP/ESP: Countering criticisms against corpus-based methodologies. *English for Specific Purposes*, 25(3), 321-332. https://doi.org/10.1016/j.esp.2004.09.002

Guillaerts, P. (2014) Schifting metadiscourse: Looking for diachronic in the abstract genre. In Bondi, M., & Lorés-Sanz, R. (Eds.), Abstracts in academic discourse: Variation and change. *Linguistic Insights*, 187, 271-287.

Halliday, M.A.K., Matthiessen, C.M. (2013). An introduction to functional grammar (3rd ed.). *Routledge,* London. https://doi.org/10.4324/9780203783771

Heard, S.B. (2022). The scientist's guide to writing: How to write more easily and effectively throughout your scientific career. *Princeton University Press*.

Heidler, L.E. (2011). NNS use of adverbs in academic writing (Thesis prepared for the degree of master of arts. English as a second language). *University of North Texas*.

Hervé This, Kientza, V., (2023). Shall we get rid of adjectives and adverbs in scientific writing? Not always. *International Journal of Molecular and Physical Gastronomy*, 12, 1-5.

Huddleston, R., Pullum, G., (2005). The Cambridge grammar of the English language. *Zeitschrift für Anglistik und Amerikanistik*, 53(2),193-194.

Hyland, K. (2005). Stance and engagement: A model of interaction in academic discourse. *Discourse Studies*, 7(2), 173-192. https://doi.org/10.1177/1461445605050365

Kaufman, L., Strauss, J. (2021). *The Blue Book of Grammar and Punctuation*: An easy-to-use guide with clear rules, real-world examples, and reproducible quizzes (12th Ed.). John Wiley & Sons, Hoboken.

Knapen, J.H., Chamba, N., Black, D. (2022). How to write and develop your astronomy research. *Nature Astronomy*, 6, 1021-1026. https://doi.org/10.1038/s41550-022-01759-z

Lewis, D.M. (2019). Grammaticalizing adverbs of English: The case of 'still'. *Crossing Linguistic Boundaries: Systemic, Synchronic and Diachronic Variation in English*, (127-149). https://doi.org/10.5040/9781350053885.ch-007

Mello, M. (2022). No, adverbs aren't ruining our scientific literature. *Scientist Sees Squirrel*.

Méndez. D. I., & Alcaraz, M. Á. (2020). Research paper abstracts in Monthly Notices of the Royal Astronomical Society (1943-2018): A diachronic approach focusing on linguistic and authorial implications. *English Text Construction*, 13(1), 62-83. https://doi.org/10.1075/etc.00035.alc

Méndez, D.I., Alcaraz, M.Á (2025a). Content words and compound structures in English-written astrophysical research paper abstracts (2011-2021). *Atlantis: Journal of the Spanish Association for Anglo-American Studies*, 47(2).

Méndez, D.I., Alcaraz, M.Á. (2025b). The use of verbs in astrophysical abstracts: Sociolinguistic implications. *Journal of Linguistics, Culture and Communication*, 3(1), 88-119. https://doi.org/10.61320/jolcc.v3i1.88-119

Merriam-Webster Dictionary (n.d.) *Adverb. In merriam-webster.com dictionary*.

Nesi, H. (2012). ESP and corpus studies. *The handbook of English for specific purposes*, (407-426). Wiley-Blackwell, Boston. https://doi.org/10.1002/9781118339855.ch21

Okulicz-Kozaryn, A. (2013). Cluttered writing: Adjectives and adverbs in academia. *Scientometrics*, 96(3), 679-681. https://doi.org/10.1007/s11192-012-0937-9

Oxford English Dictionary (n.d.) Adverb. In oed.com.

Pérez-Paredes, P.F., Sánchez-Tornel, M. (2014). Adverb use and language proficiency in young learners' writing. *International Journal of Corpus Linguistics*, 19(2), 178-200. https://doi.org/10.1075/ijcl.19.2.02per

Quirk, R., Greenbaum, S., Leech, G., Svartvik, J. (1985). *A comprehensive grammar of the English language*. Pearson Education India.

Ruan, Z. (2018). Structural compression in academic writing: An English-Chinese comparison study of complex noun phrases in research article abstracts. *Journal of English for Academic Purposes*, 36, 37-47. https://doi.org/10.1016/j.jeap.2018.09.001

Saunders, N. (2013). *Interestingly: The sentence adverbs of PubMed Central*. What You're Doing Is Rather Desperate.

Tenuta, A., Oliveira, A.L., Malveira Orfanó, B. (2014). Epistemic modality through the use of adverbs: A corpus-based study on learners' written discourse. *Letras & Letras*, 30(2), 104-121. https://doi.org/10.14393/LL60-v30n2a2014-6

Wang, W. (2023). A corpus-based study of stance adverbs in TED scientific talks. *International Journal of Linguistics, Literature & Translation*, 6(3), 189-198. https://doi.org/10.32996/ijllt.2023.6.3.21

Weinberger, C.J., Evans, J.A., Alesina, S. (2015). Ten simple (empirical) rules for writing science. *Plos Computational Biology*, 11(4), e1004205. https://doi.org/10.1371/journal.pcbi.1004205

Wen, J., Lei, L. (2022). Adjectives and adverbs in life sciences across 50 years: Implications for emotions and readability in academic texts. *Scientometrics*, 127, 4731-4749. https://doi.org/10.1007/s11192-022-04453-z

Xue, Q., Ge, T. (2021). A corpus-based study on phrasal complexity in computer science abstracts of novice and advanced writers. *Open Journal of Modern Linguistics*, 11(05), 808-822. https://doi.org/10.4236/ojml.2021.115062

Yilmaz, E., Dikilitaş, K. (2017). EFL learners' uses of adverbs in argumentative essays. *Novitas-Royal (Research on Youth and Language),* 11(1), 69-87.

Zinsser, W. (2006). *On Writing Well*, 30th Anniversary Edition.

Author Contribution Statement

Both the authors equally contributed, read and approved the final version of the manuscript.

Has this article been screened for Similarity?

Yes

Conflict of interest

The Authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.