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How to write lay summaries of research articles for wider accessibility

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Scientific Significance Statement

Scientific writing can be hard for nonspecialists to understand. Journals are trying to make findings more accessible by asking authors to write "lay summaries." These texts are intended to be more widely understood than abstracts. We show, however, that they are not more accessible due to high jargon and low readability scores of the writing. We offer tips to authors, as well as publishers and editors, for how to improve in this area. Our recommendations aim to make the summaries more easily understood by a wider range of people.

Journal articles are the key means for communicating scientific research. In the last century, science has become increasingly specialized such that journals commonly target researchers from ever narrower sub-disciplines. However, even in specialist journals, the research published can be relevant to scientists from other disciplines and to nonscientists including policymakers, managers, educators, and the general public (Knight 2003). Unfortunately, such broad audiences do not always find traditional articles easily accessible because they are written using an academic style that includes low readability of text and confusing jargon (Falkenberg and Tubb 2017).

An approach to enhance the accessibility of articles by broader audiences is the inclusion of "lay summaries" (hereafter referred to as summaries) alongside traditional abstracts. Summaries typically describe the issue studied in the paper, the research gap that was addressed, the key conclusion that addresses this gap written in general terms, and highlights the significance of the work with the goal of facilitating communication of the most important contribution of each manuscript across disciplines (e.g., *L&O Letters* https://aslopubs.onlinelibrary.wiley.com/hub/journal/23782242/about/author-guidelines, last accessed 20 December 2023; American Geophysical Union https://www.agu.org/publish-with-agu/publish/author-resources/plain-language-summary, last accessed 20 December 2023). While not replacing traditional abstracts, summaries are where authors are expected to communicate their research in less-technical ways that would appeal to new audiences (Breeze 2016). Indeed, nontechnical summaries have been advocated to increase the visibility, impact, and transparency of

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scientific research, particularly to nonscientific audiences (https://scientific-publishing.webshop.elsevier.com/publication-recognition/lay-summary-promote-work-outside-academia/#:~:text=Another%20reason%20to%20write%20a,academic%20background%20understand%20your%20work, last accessed 20 December 2023; Kuehne and Olden 2015). However, despite the goal of summaries, we know little about their accessibility to the target audiences, which can be defined by their readability and jargon content (Sharon and Baram-Tsabari 2014). Therefore, using this definition, we explore whether summaries are more accessible than abstracts, identify the guidance that journal publishers give to authors for writing summaries, and provide recommendations to authors, publishers, and editors to support the writing of article summaries with improved accessibility.

Are summaries more accessible than abstracts?

Despite the goal of summaries, we know little about their accessibility, which can be defined by the combination of their readability and jargon content (Sharon and Baram-Tsabari 2014). We define readability as "able to be read easily," and jargon as the "technical terminology or characteristic idiom of a special activity or group" (Merriam-Webster, https://www.merriam-webster.com/, last accessed 20 December 2023).

There has been some previous analysis of the accessibility of summaries. In a subset of *PLOS* journals (*PLOS Biology*, *Computational Biology*, *Genetics*, *Neglected Tropical Diseases*, and *Pathogens*) readability was not higher in summaries compared to abstracts, but summaries typically had less jargon (Breeze 2016). Less jargon in summaries compared to abstracts was also found in another analysis of articles published in *PLOS Computational Biology* and *PLOS Genetics* (Rakedzon et al. 2017).

We add additional analysis to the above studies by conducting a text analysis to quantify and compare the readability and jargon of both summaries and abstracts for 1498 articles in eight ecology and general science journals that require authors to write summaries (full details in Supporting Information). Briefly, we selected eight journals related to biology, ecology, and environmental sciences that have summaries written by the authors of the original research paper with the aim of reaching a nonspecialist audience and to emphasize the key findings and broader implications of the research (Supporting Information Table S1). For each journal we then analyzed the summaries and abstracts published in 2020 and 2021. We quantified readability using the Flesh Reading Ease (FRE) index which uses the length of words and sentences to calculate the ease of reading, with scores ranging from 0 to 100 with a score of 50 or greater recommended to enable access by nonspecialists (Hartley et al. 2004; Kirkpatrick et al. 2017). We also measured jargon by applying the De-Jargonizer (Rakedzon et al. 2017) which uses a corpus of over 90 million words and identifies "jargon" words rarely encountered by a nonsubject specialist, with a level of 2–5% unfamiliar jargon proposed to be required for accurate comprehension (Rakedzon et al. 2017 and references therein). To examine what each journal views as the "ideal" summary, we also analyzed example abstracts and summaries provided to authors. Finally, the readability and jargon were analyzed using zero-inflated mixed effects models and generalized linear mixed effects models, respectively.

We found that for most journals, summaries had a low readability that was similar to that found in abstracts (Fig. 1; for another example of this pattern, *see* Breeze 2016). The mean readability score for both text types in all journals was around 20–25, well below 50, the threshold proposed to delineate accessibility by nonspecialists (Hartley et al. 2004; Kirkpatrick et al. 2017). This low readability is not surprising, given that guidelines provided to authors for writing summaries do not emphasize characteristics that influence readability, such as sentence length or complexity (Supporting Information Table S1). Moreover, the example texts provided in the author guidelines typically also have low readability, with only one above the accessibility threshold of 50 (scores were 8, 32, 33, 33, 39, 41, and 52).

In contrast to readability, we found that authors typically use less jargon in summaries than abstracts (significantly lower for five of the eight journals considered; Fig. 1; Breeze 2016; Rakedzon et al. 2017). This decrease of jargon in summaries likely results from specific guidelines to authors that emphasize the importance of reducing jargon (Supporting Information Table S1), and because the example texts typically had low jargon close to or under the 5% threshold proposed to facilitate accessibility.

What guidelines are provided to authors?

Author guidelines provide important information to help interpret the above results. The representative eight journals we examined typically required authors to prepare relatively short summaries, most often taking the form of a single paragraph, although some are structured as bullet points. These summaries are intended to target broader audiences than the abstracts. Target audiences range from scientists from different disciplines or who were educated at the undergraduate level, to nonscientists such as decision-makers, resource managers, educators, and the general public. Finally, in all summaries, authors are requested to provide an overview of the research, with the majority also asking authors to explain the context and significance or possible implications.

Author guidelines primarily focus on reducing jargon rather than increasing readability. Six of the journal guidelines recommended removing jargon and technical language (Supporting Information Table S1), while only two journals provided guidelines on enhancing readability (e.g., shorter sentences). In addition, only three journals provided at least one (and up to six) example texts, with only one providing an

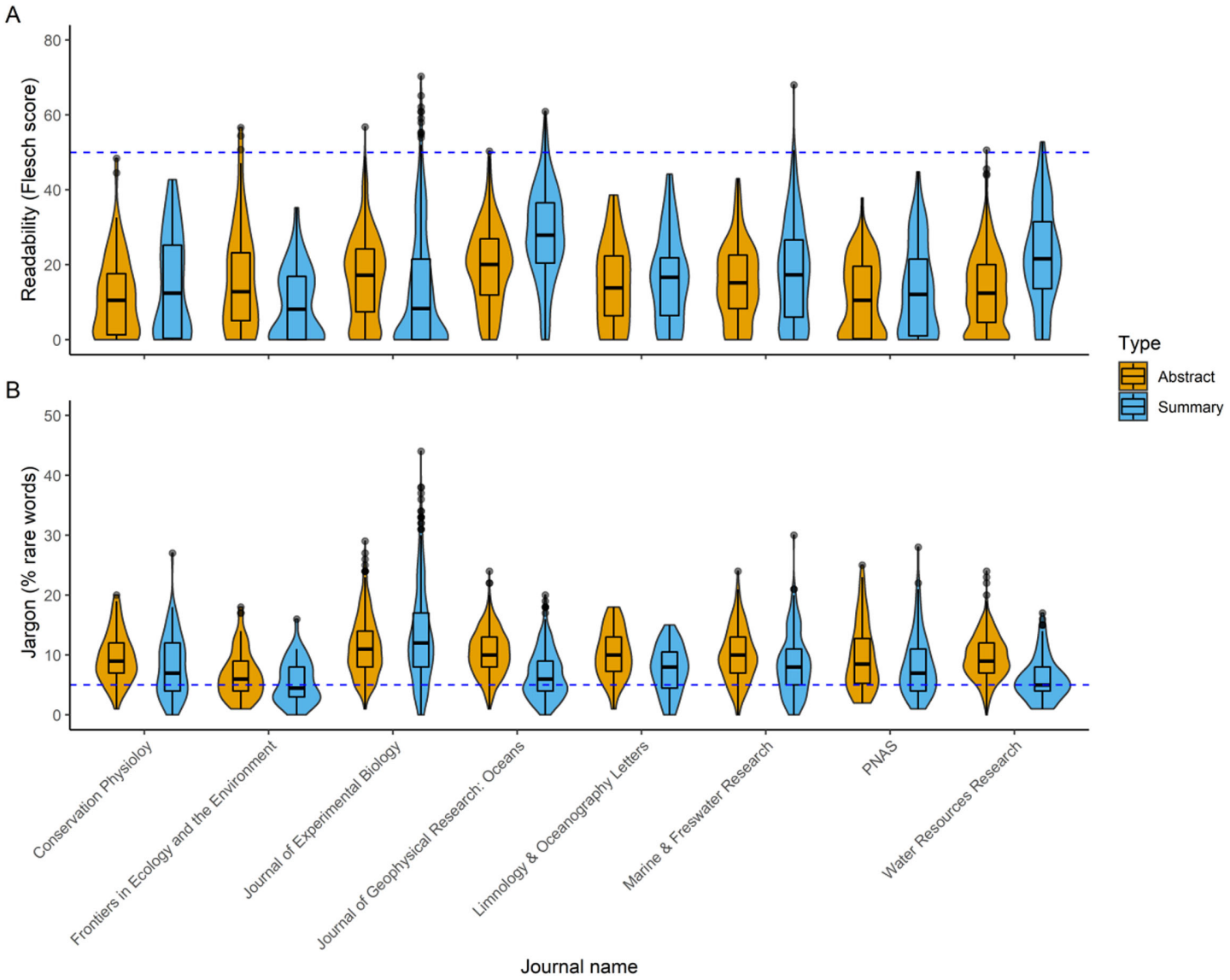

Fig. 1. The (**A**) readability (Flesch score) and (**B**) jargon (% rare words) in abstracts and summaries for a range of journals, the dashed blue line on each panel represents the limit past which the text would be accessible to a nonspecialist (i.e., readability > 50, Hartley et al. 2004; Kirkpatrick et al. 2017; jargon < 5, Rakedzon et al. 2017 and references therein).

example text specific to the journal (Supporting Information Table S1).

These results suggest that authors follow the instructions provided in author guidelines and that if the goal is to have summaries that are truly readable by nonspecialists, then actions must be taken to address the low readability of summaries. Next, we consider what actions should be taken to write more accessible summaries of scientific articles.

How to write more accessible summaries

Based on our comparison of author guidelines and text analysis of abstracts and summaries, we make the following recommendations to improve accessibility of summaries that involve not just authors, but journal publishers and editors, who must all take responsibility for ensuring more effective communication of scientific results.

Authors: Writing can improve with experience, by searching out opportunities for training, by reading published guides, and by asking for specific advice and feedback. When authors have patience and invest time and effort in such activities, they can develop the awareness and skill required to write in a style more accessible to nonspecialists.

We have three important recommendations for authors. (1) The most important factor that authors can work on to make their writing more accessible is to enhance readability. Improved readability can be achieved by writing shorter

sentences, switching from passive to active voice, and replacing long words with short alternatives. Finally, simplifying the content of writing to a key message that can be easily communicated can reduce the need for a complicated structure (Fig. 2). However, simply applying these suggestions will not necessarily make writing more readable. Authors need to make sure that the sentences and topics flow together in a logical way, otherwise the text as a whole will not be understandable, even if each sentence is improved individually.

(2) The second most important factor authors can work on is to minimize jargon, which is already emphasized in many journal guidelines. However, reducing jargon may not be as simple as it sounds as many researchers suffer from the "curse of knowledge" and they do not remember that at one point they did not understand the meaning of the terms now commonly used in their writing (Heath and Heath 2007). While common to researchers in the academic discipline, such terms are unfamiliar to nonspecialists. By putting writing through a tool such as the "dejargoniser" (described in Rakedzon et al. 2017) writers may become more aware of which terms are not commonly used and avoid using them (with this tool, jargon is defined as words that appeared less than 50 times in a corpus of over 90 million words). Authors can identify examples of these terms in their own writing by putting their text through the tool. There may, however, be terms that are shown as jargon which should be retained as they are central to understanding the piece. In such scenarios, the author would be making the choice to include jargon, rather than doing so unintentionally and inadvertently making their writing difficult for nonspecialists to understand.

(3) Finally, authors should take advantage of the growing availability of tools for improving writing. Numerous tools can assist with revisions, such as checking grammar and improving phrasing. These range from the "Spelling and Grammar" function in Microsoft Word to add-on programs, many of which are increasingly leveraging natural language processing models such as Grammarly (which we used to edit our Scientific Significance Statement), ProWritingAid, or Trinka. While the use of such tools can be controversial, if applied appropriately, and used as an intermediate step in the writing process, they can help with writing, particularly the refinement of grammar, syntax, style, and readability. Before using writing tools, authors should check with the journal policy around using these tools (if one exists), and how they are to be used and acknowledged in the submitted work. Where the use of these tools is appropriate, their use may be especially beneficial for authors with English as a second language, and it may be a development that contributes to addressing the current inequities in science related to scientific writing that is primarily conducted in English. The

Lower readability

- Write more, shorter sentences
- Replace long words with short ones
- Switch from passive to active voice
- Simplify content of each sentence to one point

Higher readability

Readability score	0–10	10–30	30–50	50–60
Grade and readability description	Professional; Extremely difficult to read	College graduate; Very difficult to read	College; Difficult to read	10th to 12th grade; Fairly difficult to read
Example	Aquatic science scholarly research, decision-making for management purposes, and environmental policy decisions all incorporate insights gained from complementary research disciplines. Unfortunately, most academic research manuscripts are prepared with specialist readerships in mind, hindering comprehension by readers from other disciplines outside of academic contexts. Inclusion of a "lay summary" for articles is one way some journals are attempting to overcome these barriers and although this approach facilitates some improvement it is not the panacea – jargon is typically still high and readability is similar. Therefore, the authors of the current article offer recommendations for various stakeholders of academic publishing to be cognizant of for improving their ability to meet expectations and enhance the understanding, recognition, and use of scientific research for interdisciplinary studies and decision-making.	Scientific writing can be hard to understand for those outside the specialized field. Inclusion of a "lay summary" for articles is one way some journals are attempting to overcome these barriers. Although this approach facilitates some improvement not all barriers are overcome as there is still relatively high jargon and readability is typically similar. Therefore, the authors of the current article offer recommendations for various stakeholders of academic publishing to be aware of for improving their ability to meet expectations and enable the incorporation of research in interdisciplinary contexts.	Scientific writing can be hard to understand for those outside the specialized field. Journals are trying to make the findings more accessible with "lay summaries," but we show that there can still be barriers due to the high jargon and low readability of them. We offer recommendations to not only authors, but also journal publishers and editors to make these summaries more accessible and, therefore, the underlying research understood by a wider range of audiences.	Scientific writing can be hard for non-specialists to understand. Journals are trying to make findings more accessible by asking authors to write "lay summaries." These texts are intended to be more widely understood than abstracts. We show, however, that they are not more accessible due to high jargon and low readability scores of the writing. We offer tips to authors, as well as publishers and editors, for how to improve in this area. Our recommendations aim to make the summaries more easily understood by a wider range of people.

Fig. 2. An example of a Scientific Significance Statement as it may be written with different levels of readability.

suggestions provided by these tools need to be carefully evaluated, and edited by the author, typically in an iterative way with the tool to ensure that the correct and primary message is maintained and presented.

Journal publishers and editors: We have two main recommendations for journal publishers and editors to help authors. (1) Journals should provide more detailed and specific instructions on writing effective summaries in their author guidelines, including topics beyond just jargon (examined in Kirkpatrick et al. 2017). For example, in many of the journals we studied, the guidelines ask authors to avoid using acronyms and complex scientific terms, but there is no direct instruction as to sentence structure or readability (Supporting Information Table S1). To increase readability, author guidelines should include those aspects noted above (i.e., writing shorter sentences, using the active voice, using short words, and including one simple idea per sentence). The absence of these suggestions may be why readability is not higher in summaries compared to abstracts. Supporting these instructions could be information of tools that can be used to assess key characteristics of writing along with their specific target scores, such as the FRE index or "dejargoniser" (described in Rakedzon et al. 2017).

At least one journal that we analyzed appears to successfully connect author guidelines with expected outcomes related to jargon in both abstracts and summaries. For example, *Frontiers in Ecology and the Environment* had a proportion of jargon in both abstracts and summaries that would allow comprehension by nonspecialists. This low amount of jargon could reflect clear author guidelines that prompt authors to write articles (as well as summaries) that are "less 'traditionally academic' than many other journals" and it is "crucial that the language contained within your manuscript be as clear and accessible as possible" (https://www.esa.org/frontiers-in-ecology-and-the-environment/author-guidelines/, last accessed 20 December 2023).

(2) Journals should provide example summaries that are exemplars of high readability and low jargon, preferably on topics related to the journal. Although the example summaries that journals provided had jargon close to or below levels that were accessible to a general audience, their readability was rarely close to recommended levels, which could lead authors to perceive that this metric is not important for improving accessibility. Consequently, if the publisher or editor desires change in a key metric that can influence accessibility—specifically readability—we suggest it would be important to adjust the example texts.

Additional steps could be taken to ensure these guidelines are followed by having editorial staff members, reviewers, or independent scientific writers comment on submitted texts. If included as part of the peer-review process, reviewers should be given clear guidelines on what they should assess the summaries in terms of and if this should include readability and jargon. Moreover, journals could potentially more clearly indicate the intended purpose of such summaries is by carefully considering the naming of these texts (i.e., we found they are referred to variously as a "Lay Summary," "In a Nutshell," "Summary Statement," "Plain Language Summary," "Scientific Significance Statement," or "Significance Statement"; Supporting Information Table S1).

Ultimately, however, good writing is about more than just readability and jargon

Summaries give authors a unique opportunity to complement their traditional academic writing with descriptions tailored to capture broader audiences. Unfortunately, summaries are currently written in a style that limits accessibility. Changing the writing habits of authors to create more accessible summaries requires time, effort, and money. We suggest that authors, journal publishers, and editors should all support these efforts to ensure summaries meet their intended goals. In particular, editors must ensure that their guidelines and examples reflect the readability and jargon they seek. This increased attention is important because more accessible writing will allow scientists to communicate better across disciplinary boundaries and to broader, nonscientific audiences, increasing the visibility, impact, and influence of research products.

Here, we have focused on quantifying the readability and jargon of summaries as a way to assess their accessibility to general audiences. However, it will be important to ensure that writing to enhance these features does not impair other features that are also important. Many metrics can be used to characterize the "style" of academic writing—including word count, setting, narrator, conjunctions, signposting, punctuation, consistent language, parallel phrasing, hedging, acronyms, noun chunks—which all have suggested approaches to improve impact (Freeling et al. 2019). While we have emphasized the role of quantifying writing characteristics here, condensing writing to a set of measurable characteristics does not capture everything that is good or bad about writing, complicating improving our writing style.

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Conflict of interest

None declared.

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