



The use of artificial intelligence to improve the scientific writing of non-native english speakers

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SUMMARY

OBJECTIVE: Scientific writing in English is a daunting task for non-native English speakers. The challenges of writing in a foreign language are evident in the scientific literature where texts by non-native English-speaking scientists tend to be less clear and succinct, contain grammatical errors, and are often rejected by prestigious journals.

METHODS: We conducted a non-systematic review of the most recent literature using the terms “Artificial Intelligence,” “Scientific Writing,” and “Non-English Speaking” to create a narrative review.

RESULTS: Artificial intelligence can be a solution to improve scientific writing, especially for non-native English-speaking scientists. Artificial intelligence can assist in the search for pertinent scientific papers, generate summaries, and help with the writing of different sections of the manuscript, including the abstract, introduction, methods, results, and discussion. Artificial intelligence-based programs can correct grammatical errors and improve writing style, both of which are particularly helpful for non-native English speakers. Two artificial intelligence programs that can help with the search for pertinent scientific papers on the internet are Elicit and ResearchRabbit. Scispace Copilot can be used to summarize the retrieved reference. The artificial intelligence software programs such as Grammarly and Paperpal can correct grammatical and spelling errors, while ChatGPT can also restructure sentences and paragraphs, reword text, and suggest appropriate words and phrases.

CONCLUSION: Overall, artificial intelligence can be an effective tool to improve the clarity, style, and coherence of scientific writing, helping non-native English-speaking scientists to communicate their research more effectively.

KEYWORDS: Artificial intelligence. Language. Writing, medical. Internet.

INTRODUCTION

Most scientific papers in the world literature are written in English¹ by non-native English speakers². Non-native English-speaking scientists face many difficulties in writing clearly, succinctly, and without grammatical errors^{3,4}. Nevertheless, despite the use of word processors and spell checkers, the final text still does not compare favorably with those created by native English speakers, thus contributing to the lower chances of acceptance of these papers in prestigious scientific journals^{5,6}.

Artificial intelligence (AI) involves the development of algorithms and computer programs that can learn from and make predictions or decisions based on real-world data, mimicking human intelligence. Furthermore, AI systems can be trained to recognize data patterns, make predictions, and learn from experience. AI can thus perform tasks that typically require human-like reasoning and decision-making.

Natural language processing is a type of AI that enables machines to understand, interpret, and generate human language in a manner that is natural to humans^{7,8}. For example,

ChatGPT (Generative Pre-Trained Transformer) is a language model developed by OpenAI that was designed to generate natural language responses to text prompts. In addition, ChatGPT's underlying AI system is pre-trained on vast amounts of text data from the Internet that enables it to learn the patterns and structures of languages. Therefore, it learns how to generate coherent and contextually appropriate responses to a wide range of text prompts.

With all these capabilities, the AI programs can assist scientists in the search for pertinent scientific papers on the Internet, summarize them, and help with the writing of abstracts, titles, and parts of the introduction, methods, results, and discussion. In addition, the AI programs can correct mistakes and improve the writing style of previously written texts, both of which are particularly helpful to non-native English-speaking scientists⁹⁻¹².

In this paper, we will briefly describe how AI-based programs can help with the preparation of research papers, especially considering how they can help improve scientific writing skills.

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METHODS

Due to the very recent widespread access to AI-based programs such as ChatGPT, there was not enough evidence in the medical literature to pursue with a systematic review. We therefore elected to conduct a non-systematic review of the most recent literature using the terms “Artificial Intelligence,” “Scientific Writing,” and “Non-English Speaking” to create a narrative review using Google Scholar, Google, and AI-powered reference retrieval programs such as Elicit (www.elicit.org) and ResearchRabbit (<https://www.researchrabbit.ai/>).

RESULTS

Artificial intelligence programs supporting scientific writing

Drafting a research manuscript entails several steps to be taken after the scientist has all the experimental or clinical trial results already tabulated, analyzed, and displayed in tables and/or figures. It is also important to conduct a recent and thorough review of the literature and have all the references that will be used in the paper stored in the citation software for future use. Most of the experts then suggest writing the results, followed by methodology sections^{13,14}. These sections are the easiest ones to write as they are readily available to the researcher when he or she becomes ready to start drafting the paper. Therefore, these sections, which represent the essence of the paper, are not going to benefit as much from AI text-generating capabilities, but they still can be much improved by AI-powered grammar and spelling correctors. Then comes the discussion section and finally the introduction, abstract,

and title^{13,14}. These parts of a paper can be drafted with AI help, once the AI-powered program is fed with the methods and results previously written. Several authors have already outlined which are the parts that every one of the sections should have and what type of content they should include for a paper to convey all the scientific information properly and clearly as it is expected to report¹⁵⁻¹⁸.

Artificial intelligence and bibliographic reference

Before even starting to write a paper, it is necessary to assemble all the pertinent references already published in the literature to learn about the field and at the same time to find still unanswered questions that can be the subject of future research. AI is particularly useful for this purpose, as it can find references related to a specific article from its content, authors, or citations and quickly build a new list of references that would otherwise be much more difficult to collect. Two AI programs can be helpful for this purpose, namely, ResearchRabbit (<https://www.researchrabbit.ai/>) (Figure 1) and Elicit (www.elicit.org). Both programs will suggest references many times not yet known by the scientist because they can go “beyond the horizon” by a self-learning approach based on several retrieved papers using their contents, keywords, and citations¹⁹ to retrieve other papers.

AI can also help summarizing selected references by using both Elicit and Scispace Copilot (<https://typeset.io/>). Scispace Copilot is an AI chrome extension that can also explain highlighted parts of a paper and the statistical results obtained and allows the scientist to ask his own questions regarding the text.

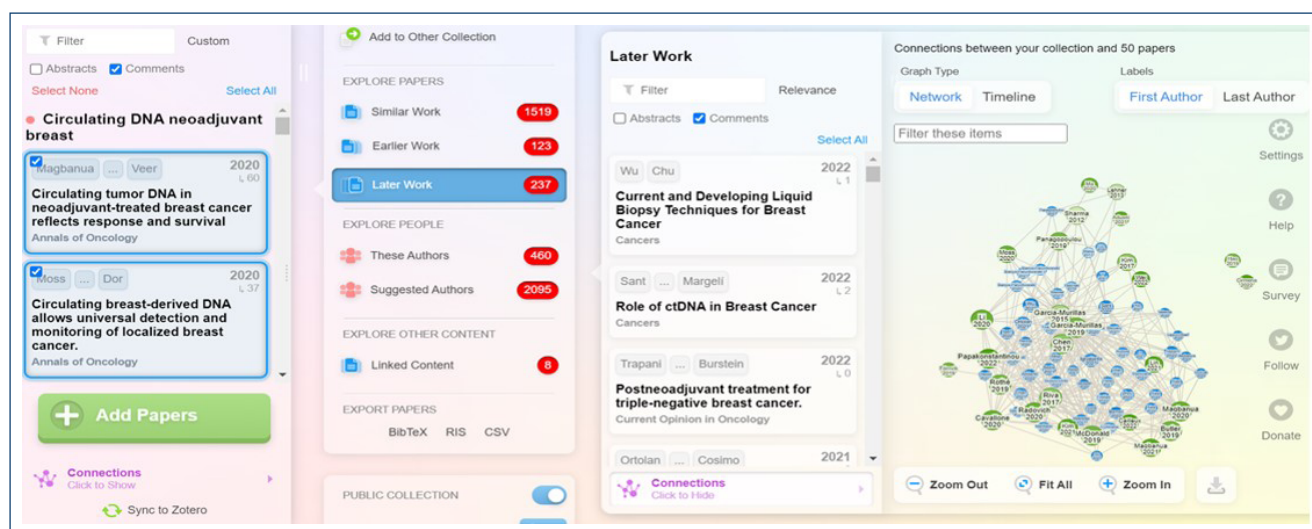


Figure 1. Reference searching with ResearchRabbit.

All the selected papers should then be stored in a reference management system (RMS). Although RMSs do not normally use AI, they are powerful tools to help in scientific writing. Examples of RMSs are Zotero (www.zotero.org) and Mendeley (www.mendeley.com), both of which are free and compatible with the most widely used word processors such as Microsoft Word. Zotero can also be used with Google Docs. Zotero and Mendeley allow the scientist to store his or her notes on each of the stored papers that could be useful later when writing the paper. Both these RMSs can import articles found with Elicit and ResearchRabbit. Many other RMSs such as Endnote and Paperpile, which are widely used by scientists, are not free. With the help of the RMS software, we can insert citations in the text as we are writing it and at the end of the paper produce a bibliography including all references that were cited in the text in a specific format such as Vancouver. Moreover, if editing changes are made later in the paper, these RMSs can automatically change the order of the references in the text and the bibliography.

Artificial intelligence and correction and improvement of english texts

Several software programs also use AI that can correct grammatical and spelling errors as well as improve the text with suggestions such as Grammarly (app.grammarly.com) and Paperpal (www.paperpal.com). Despite suggesting useful changes in the text, these programs, however, do not change the main structure of the article or generate new text. The AI tools such as ChatGPT, however, can correct spelling, punctuation, and grammatical errors; in addition, it can also summarize the text, paraphrase it, and even create a section of a paper based on another, for example, creating an abstract or an introduction based on the results of the paper. Most interesting to us is the possibility of

a non-native English speaker loading his text into ChatGPT and asking the AI program to improve it so that it will not be perceived anymore as a paper written by a foreigner. ChatGPT can also write code to analyze data present in a Microsoft Excel spreadsheet or in a statistical program such as R and advise on what statistical tests to use to analyze data and help explain the obtained results.

ChatGPT works with prompts and knowing some of them as related to scientific writing may be especially useful to maximize its output toward a desired goal. For instance, before loading the text of a paper or a section of it to ChatGPT within quotation marks, we can ask the AI program to proceed with several tasks through prompts that we type in the chatbot window. For example, we can ask ChatGPT to summarize the following paper “paste the text of the paper here.” Likewise, we can ask it to Create an introduction; Create a title; Create 250 words abstract; Reduce an abstract; Create a title for an abstract (Figure 2); Create a discussion; and so on.

ChatGPT is a very promising resource and will certainly improve with all the technological improvements that can be foreseen in the next few years. Nevertheless, we can already point out some of the advantages and potential disadvantages that it can bring to scientific writing (Table 1).

Ethical considerations

AI can help the scientist in these steps differently. In fact, at present, AI can be an accessory, a facilitator, but should never be expected to write any of the sections of a scientific paper as an author would. As amazing as it can be that AI-generated output can be rapidly produced, grammatically correct, and sometimes even insightful in terms of its content, several errors can occur that limit the usefulness of AI-generated texts without due correction and editing¹⁰.

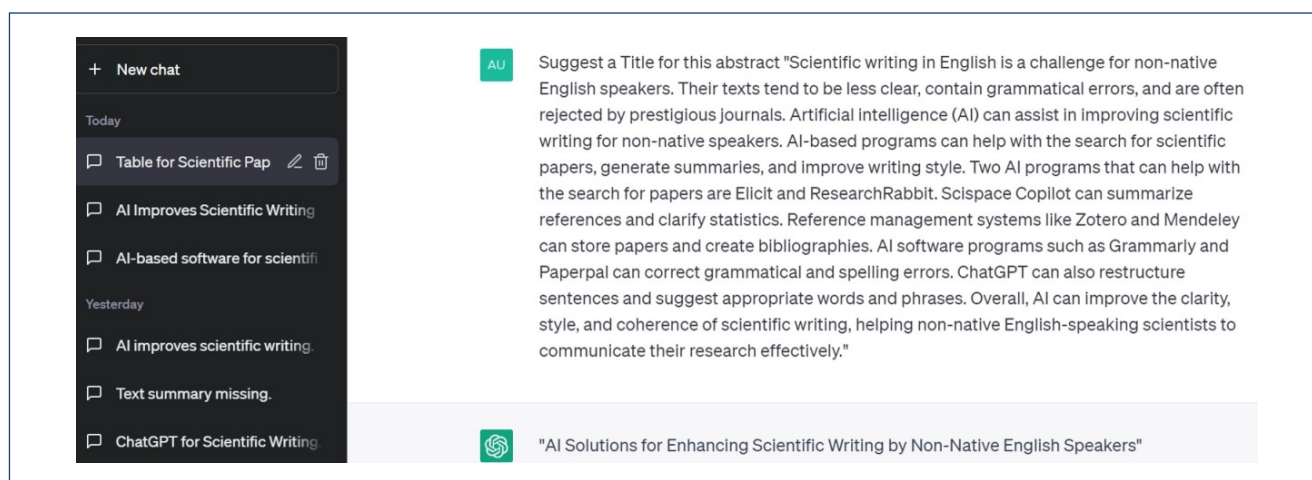


Figure 2. Using ChatGPT for creating a title for an abstract.

Table 1. Benefits and disadvantages of the artificial intelligence software programs in scientific writing.

Benefits	Disadvantages
AI-based programs can help break mental logjams when writing by suggesting a first draft of a text. These programs can also enhance readability by breaking up a difficult topic into smaller pieces.	Incapable of understanding added information, generating novel insights and deep analysis which would limit the discussion within a scientific paper. AI tools are more adequate for regurgitating conventional wisdom than for identifying or generating unique outcomes.
Programs such as Elicit or ResearchRabbit can identify references for a specific topic that might be missed by conventional literature searches.	Superficial, and over-reliance on the output could decrease scientific creativity by reducing the impact of papers in generating real contributions to a specific knowledge field.
Be used effectively to improve your manuscript's title, abstract, and conclusion and tailor it to match the journal parameters and better match its scope or readership.	AI might be worse at assessing whether a unique outcome is spurious or ground-breaking. Therefore, reliance upon AI for this purpose will reduce the frequency of future disruptive scientific breakthrough.
Help a writer be more thorough when covering a topic by reminding them of aspects they had not considered and by providing knowledge in areas not yet familiar to the author in an easy and understandable way.	AI-based programs may harm the development of writing skills by young researchers and facilitate plagiarism.
Facilitating composition by non-native English speakers and decreasing inequalities existing with native-speaking researchers. The language resources of AI will certainly be included soon directly in other interfaces, such as Microsoft Office 365.	
Develop code for Python and other programs such as R and Excel. This code-generating ability can help in the analysis of statistical data and in creating figures to represent experimental results.	

ChatGPT cannot be considered a coauthor in a scientific paper. Authorship requires contributions to the conception, design, analysis, interpretation, and writing and approval of a definitive version of the manuscript. Furthermore, authorship also requires that authors take public responsibility for the content of the paper²⁰. As ChatGPT cannot be responsible for what it writes, the responsibility regarding the content of a scientific paper rests completely upon all the human coauthors who must check and edit all the generated content.

Nevertheless, it is the authors' opinion that the editorial help provided by the AI-powered software programs such as ChatGPT can be of use to improve their writing. Authors need, however, to properly disclose at the end of the paper in which of the article's sections the AI-powered software programs were used and for what reasons. In addition, it is important to state that AI-generated output was duly checked by the authors. Acknowledgment regarding the responsibility for all the paper content needs to be explicitly recognized by all the authors as well. We believe that, if all these precautions are taken, AI can be safely and productively used by non-native English-speaking researchers to improve their scientific writing^{21,22}. At the end of this paper, we added a paragraph based on a model suggested by Elsevier Company²¹ to acknowledge the use of AI in this article that may be used by other researchers as well.

Another ethical concern with AI-generated texts is the potential for plagiarism²². Plagiarism detectors exist²³ to help in

identifying texts or parts of texts that were copied from other sources. Unfortunately, however, automatic rephrasing of paragraphs can potentially elude plagiarism detection²⁴. A potential problem with this technology that can circumvent plagiarism detection is the proliferation of papers with few real contributions to add to the overall knowledge that may further contribute to the relative decrease in scientific breakthroughs we are currently observing²⁵.

CONCLUSION

Writing scientific articles in English is a challenging task for non-native speakers. However, with the help of the AI tools, non-native English speakers can improve the clarity, style, and coherence of their writing. The AI-based programs can assist with various aspects of the scientific writing process, including searching for relevant papers, generating summaries, correcting grammatical errors, improving writing style, and creating bibliographies. Elicit, ResearchRabbit, Scispace Copilot, Zotero, Mendeley, Grammarly, Paperpal, and ChatGPT are some of the AI tools that can be particularly helpful for non-native English-speaking scientists. Using the AI-powered software programs can not only enhance the quality of scientific writing but also help researchers produce papers with higher chances of publication in major scientific journals and thus help effectively communicate their research to a wider audience.

Artificial intelligence disclosure

During the preparation of this work, the authors used CHATGPT to generate a draft of the abstract and conclusion sections. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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AUTHORS' CONTRIBUTIONS

ADG: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing. **MUPC:** Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing.

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