



Risks of abuse of large language models, like ChatGPT, in scientific publishing: Authorship, predatory publishing, and paper mills

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Key points:

- Academia is already witnessing the abuse of authorship in papers with text generated by large language models (LLMs) such as ChatGPT.
- LLM-generated text is testing the limits of publishing ethics as we traditionally know it.
- We alert the community to imminent risks of LLM technologies, like ChatGPT, for amplifying the predatory publishing 'industry'.
- The abuse of ChatGPT for the paper mill industry cannot be over-emphasized.
- Detection of LLM-generated text is the responsibility of editors and journals/publishers.

Keywords: authorship abuses, ChatGPT, ghost authorship, large language model, paper mills, predatory publishing

ChatGPT IN ACADEMIA: AUTHORSHIP OF ACADEMIC PAPERS, LIMITATIONS AND CONCERNS

Alan Turing, who conceived the modern computer in 1936 (Turing, 1937), also made important contributions to computer science and artificial intelligence (AI) (Copeland & Proudfoot, 1999). In the Turing Test, Turing asked whether machines could think, claiming that logical communication with machines would be possible by the end of the 20th century, as assessed by the Imitation Game (Turing, 1950). Some consider that large language models (LLMs), such as ChatGPT, have already passed the Turing Test, and now exhibit 'intelligence', although this is another philosophical debate (Sejnowski, 2023). Questions abound about how ChatGPT might affect knowledge sectors outside of research (Gordijn & Have, 2023), such as software development (Castelvecchi, 2022) or education assignments (Stokel-Walker, 2022).

There is still some way to go before tools such as ChatGPT, which we focus on in this paper, are universally considered to be

'intelligent', although we believe that the introduction of ChatGPT is a significant milestone, and it may change some aspects of how humans interact with computers and the range of services they provide. ChatGPT is already being used by scholars to help them develop research proposals, ask questions, and write articles (Chen, 2023), but other AI-driven LLMs like Google Bard, Microsoft Bing AI and Jasper.ai are also in competitive use. OpenAI's GPT-3, the third version of ChatGPT, was released in June 2020 while GPT-4 was released on 14 March 2023 (Lund & Wang, 2023). ChatGPT has already received considerable attention from scholars, and a search in Scopus for 'ChatGPT' in the Article Title, Abstract or Keywords returned 1,254 results (13 August 2023), with 1,250 of those publications in 2023, and only four papers from 2022.

Lee (2023) and Nature (2023) both note that a chatbot cannot be listed as an author as its work cannot be copyrighted, so it cannot be the author on copyrighted work. Yeo-Teh and Tang (2023) noted that an AI-based LLM cannot be listed as an author because it does not fulfil popular authorship guidelines, at

least in the biomedical sciences, such as those by the International Committee of Medical Journal Editors (ICMJE), especially the aspect of accountability (Nature, 2023; Teixeira da Silva, 2023a; Teixeira da Silva & Tsigaris, 2023). Not only can ChatGPT and LLMs not be authors of academic papers, but their use (or reliance on them) must be explicitly acknowledged in academic papers (Brainard, 2023), although this relies on a 'dangerous' precedent, namely total and implicit trust in authors' honesty, a topic we discuss in more detail later. Several publishers have put policies in place to limit the author-based recognition offered to ChatGPT and LLMs (Dwivedi et al., 2023; Teixeira da Silva & Tsigaris, 2023). It is now widely recognized by the publishing industry, at least those journals that subscribe to guidelines and recommendations by organizations such as the Committee on Publication Ethics (COPE),¹ ICMJE,² or the World Association of Medical Editors (WAME),³ that AI or LLMs cannot be considered authors of academic papers. This is similar in function to policies in place to ensure that assistance with writing and editing papers is acknowledged, although these policies still suffer from deficiencies in practice, such as verification (Kendall et al., 2016; Teixeira da Silva, 2021a). The same challenge will be met by academia in being able to detect LLM- or ChatGPT-derived text in papers that claimed to use such AI, and also in papers that did not declare the use of such software (Teixeira da Silva, 2023b). In essence, we challenge the journals in which the 1,254 papers published thus far to show evidence that they have screened the text to appreciate which was written by humans, and which by AI. We suspect that such evidence will not be forthcoming.

In this paragraph, we focus on the issue of legitimate versus illegitimate cases of authorship in the context of AI-, LLM-, or ChatGPT-derived text. Although ChatGPT has been given credit for authoring papers (Stokel-Walker, 2023), an unknown number of which cannot be verified by ORCID (Teixeira da Silva, 2023c), there are already authorship discrepancies and problematic cases that conflict with established codes of conduct and ethical regulations. In one example, a preprint lists ChatGPT as an author (Kung et al., 2022) whereas the published version of the paper excluded it as an author (Kung et al., 2023). A published article that listed ChatGPT as an author was corrected to remove it as the second 'author' (O'Connor, 2023). Despite these cases, to our knowledge, there have not yet been any ethical repercussions for either the human authors or ChatGPT, such as retractions. However, we point to a case in which apparently fictitious ChatGPT-'created' references led to the retraction of a preprint, and the blacklisting of the authors.⁴ It has also been argued that

authors should declare the proportion of content that has been AI-generated and that an excessive amount could be regarded as academic misconduct (Tang, 2023). Although it is claimed that text written by ChatGPT can be detected (Cingillioglu, 2023; Desaire et al., 2023), detection will become more difficult as LLM tools develop, even with the use of watermarking (Anderson et al., 2023; Brainard, 2023). Hu (2023) claimed that AI-generated papers are not easily discernible to the human eye, and ChatGPT has already demonstrated that it can write abstracts that are capable of fooling scientists (Gao et al., 2023). If true, as was argued above, no number of rules and regulations will deter academics willing to abuse LLMs to advance their academic careers. Otterbacher (2023) argues that technical solutions are not sufficient for detecting AI-generated content and that ways to use generative AI should be part of an academic culture that supports their use in creative and ethical ways. Nature (2023) says that researchers using generative tools should acknowledge their use in the paper.

Even though AI is already used to write scientific papers, it should not replace researchers' expertise and judgement (Salvagno et al., 2023). Owens (2023) surveyed how researchers are using generative AI, such as ChatGPT, to help with their research: 57% of the respondents said they used it for creative fun, not related to research, 24% used it for writing computer code, while 16% used ChatGPT to help with their research. ChatGPT was used to draft a research paper, to discuss the statistical analysis that needed to be undertaken, and to generate algorithmic code (Macdonald et al., 2023). ChatGPT generated two papers but there were some issues with the results, such as falsified references (Anderson et al., 2023), as was noted above for the retracted preprint. ChatGPT was impressive in terms of generating ideas and data identification, but it showed a weak literature synthesis (Dowling & Lucey, 2023). ChatGPT, or its use by academics in scientific writing, may pose a threat to scientific integrity, or at least the integrity of the knowledge within papers that are labelled as being 'scientific' because the output might not be accurate or correct, so fact-checking, detection of plagiarism, and grammatical coherence are in the hands of academics (Lancet Digital Health, 2023; Liebrezn et al., 2023). This will have knock-on effects on the integrity and reliability of systematic reviews and meta-analyses if LLM-derived papers are cited in such papers, thereby 'contaminating' them. van Dis et al. (2023) suggested that LLMs might be able to conduct peer review and support editors when deciding whether to accept or reject a paper. This use of ChatGPT is already a matter for discussion (Donker, 2023; Garcia, 2023).

A counter proposal to researchers writing scientific papers was proposed by Habibzadeh (2023). The argument is that there will be too much data for humans to analyse and a universal AI system (UniAI) will replace the need for journals, indexes, peer review, ethical considerations, and editors. Instead, questions will be posed and UniAI will access all available data and return the result in real time. This may include knowledge gaps, which can then be further investigated.

¹<https://publicationethics.org/cope-position-statements/ai-author> (last accessed: 14 August 2023).

²<https://www.icmje.org/icmje-recommendations.pdf> (last accessed: 14 August 2023).

³<https://wame.org/page3.php?id=106> (last accessed: 14 August 2023).

⁴<https://www.preprints.org/manuscript/202306.1339/v1>; backstory: <https://retractionwatch.com/2023/07/07/publisher-blacklists-authors-after-preprint-cites-made-up-studies/> (7 July 2023; last accessed: 14 August 2023).

The use of ChatGPT is inevitable and trying to ban it will be a futile exercise, but better management of its use can be achieved by researchers remaining vigilant as the information provided by ChatGPT might not be correct, may be plagiarized, or may have been inferred incorrectly, or it may be biased due to the way in which a question is phrased, noting a possible risk of the use of ChatGPT by paper mills and predatory journals (van Dis et al., 2023). Choudhury and Shamszade (2023) highlighted the importance of trust in generative AI tools. Rigorous ethical policies, integrity, honesty, and transparency are essential to guide and monitor the use of LLMs and ChatGPT (van Dis et al., 2023).

The threat of GPT, as a 'robo-writer', is not new (Hutson, 2021). Moreover, the ability to use LLMs for academic cheating, especially in the creation of fake papers, using 'paper generators', is also not new, and has been used for some 'sting' operations. These operations are when authors, perhaps using a pseudonym, submit a paper, which should not pass peer review, in order to demonstrate the unethical practices of the journal should the paper be accepted. Some consider these operations to be unethical (Al-Khatib & Teixeira da Silva, 2016). One such software, SCIfgen, generates random papers with nonsense text that might confuse novice researchers or non-experts, and may serve as a tool to avoid the detection of plagiarism. By 2014, 120 SCIfgen-generated papers were retracted (Labbé & Labbé, 2013), and by 2021, even though 243 'nonsense' papers were detected, only 19% of them had been retracted (Cabanac & Labbé, 2021). This suggests that even though there may eventually be AI that is capable of effectively detecting ChatGPT, papers that have abused the use of LLMs, or that have inappropriately claimed authorship, even though ChatGPT is the true generator of such text, such papers might not be retracted due to ethical infractions. Time will tell. In the meantime, we raise a concern with the case of a medical practitioner who employed ChatGPT to write, on his behalf, 16 papers within the first quarter of 2023 alone (Tran, 2023). This concern is intricately linked to the ability of journals to detect ChatGPT-generated text, to present evidence of human- versus LLM-derived text, and then to take action against authors who have violated stated ethical guidelines, as was argued above. One concern we have is how much content in papers is generated by AI, especially papers that might lie outside of the author's field of expertise and which, presumably, could not be defended or explained to a knowledgeable audience.

CHATGPT FROM THE PRISM OF PREDATORY PUBLISHING AND PAPER MILLS: WHO MIGHT THE BENEFICIARIES AND LOSERS BE?

Although some authors have argued that the use of ChatGPT would disadvantage non-native English speakers because the skills of native English speakers would be amplified (Liang et al., 2023), others have argued that it would benefit them by offering a competitive advantage versus native English speakers (Huang & Tan, 2023). We note, as a curiosity, that the majority of

the paper written by the latter pair of authors was in fact generated by ChatGPT, and even though this assistance was acknowledged, we side with the opinion of Tang (2023) that excessive reliance on ChatGPT, basically to substitute for an author's ability to write a scientific paper, should be considered misconduct; that is, authorship of the human authors should be invalidated since very limited intellectual reflection is involved other than screening and editing ChatGPT's output. With a striking amplification of papers partially or mostly written by ChatGPT, we confidently declare that a new war in, and on, academic publishing has now officially begun. We believe that this threat should not be underestimated, even as ample possibilities for achieving 'good' or 'novel' ideas arise.

At this junction of our reflections, we predict that native English speakers, or those with moderate-to-high levels of intellectual capacity and experience, even if they are not necessarily native English speakers, will use LLMs like ChatGPT to amplify their publication profiles, aiming for journals that are ranked and indexed, inevitably aiming for higher-ranked journals based on the logic that a paper with strong scientific merit but that is badly written would likely not be accepted for publication in a high-ranking journal, as equally as a well-written paper but with weak scientific evidence. We also predict that authors who are not native English speakers, but who have high publishing ambitions, will turn to LLMs like ChatGPT to potentially generate 'masses' of papers (we refer to these as pseudo-academic papers) that might not pass peer review in rigorously reviewed indexed journals, but that might get an easy route in so-called 'predatory' journals, or even in indexed journals that have no or poor screening procedures in place. The second abuse that we envision is the amplified business by 'paper mills', which generate papers and fake content, for a price (Sabel et al., 2023). These authorship and publication abuses ultimately arise due to the commodification of science, scientific knowledge, and the publication process.

The identification and/or classification of a predatory journal or publisher is a challenging task that is currently not effectively being achieved by the scientific community. Beall's lists (Beall, 2017; Kendall, 2021) were popular 'go-to' resources, but since Beall shut down the blog that housed them in 2017, they are now redundant, outdated, and thus of little academic use, and their use in some academic papers may invalidate their methodology and findings (Teixeira da Silva & Kendall, 2023a). Moreover, an AI-driven software that also claims to effectively discern 'normal' from 'suspected predatory' journals also currently gives an apparently high false positive output, and thus the serious problem of journal misclassification, which can severely damage their reputations if characterizations are not accurate, or substantiated (Teixeira da Silva & Kendall, 2023b). There are concerns, however, that perceived academic and scholarly databases, like Scopus, may have indexed potentially 'predatory' journals (Macháček & Srholec, 2022) while public medical scientific information accumulators, like PubMed, might be infiltrated by information and knowledge that has not been properly vetted, including in journals that may be 'predatory' (Teixeira da Silva, 2023d). As previously noted, there is no consensus on

whether it is possible to detect AI-generated text, with some claiming it is possible while others claim it is not. We believe, like plagiarism, that we are entering (if not already there) an arms race, where both those who wish to detect AI-generated text, and those who wish to conceal this fact will develop ever more sophisticated tools and methodologies. Journals and their editors, in their enthusiasm to publish papers on ChatGPT—given its hot topicality—may be placing the integrity of the scientific literature at risk by flooding it with pseudo-academic papers, or with papers generated mostly by LLMs. Absent rigorous control measures, and stringent post-publication penalties for authorship and information abuses, such as retractions, we envision that databases and platforms like Scopus, Web of Science, PubMed, and Google Scholar will become awash with papers infused with ChatGPT-derived text. In such cases, should those who abused ChatGPT's skills to their advantage, and yet suffer retractions, exist in a shame-free milieu (Hu & Xu, 2023)? To our knowledge, peer reviewers have no tools at their disposal to detect LLM- or ChatGPT-derived text—a responsibility that should be lie squarely with publishers (Teixeira da Silva, 2023b)—further weakening the 'peer-reviewed' brand. Without trying to sound overly alarmist, if the leadership and members of the current status quo (COPE, STM, ICMJE, DOAJ, OASPA, etc.) do not take immediate, industry-wide, and concerted action *now*, the damage to the integrity of scientific knowledge may be too large to reverse or even correct.

We can envision at least a two-pronged scenario: on the one hand, journals and their editors who take ethics and publishing standards seriously, and who will put in place any and whatever tools are available to screen papers to detect ChatGPT-derived text; on the other hand, unscrupulous players, such as predatory journals and paper mills (Byrne et al., 2022), who might abuse the principles of trust, honesty, valid and dedicated authorship, and scientific contribution, in the following ways:

- Papers that have not been peer reviewed or that were 'written' by ChatGPT may be cited by legitimate literature or populate the scholarly archive, alongside legitimate academic papers.
- Abuse of funding, such as for the payment of open access article processing charges (APCs), to push through ideas that are not generated by the authors entirely, but are, within minutes of a query, generated by ChatGPT. The economic returns on the temporal investment are huge. At the same time, funding for APCs, which can range in the hundreds or thousands of US\$ per paper (Grossmann & Brembs, 2021), could be a waste of tax-payers' money. Governments, therefore, have a responsibility to ensure that their citizens' funds are not being squandered.
- Amplification of the publish or perish culture, pushing authors to becoming hyper-competitive (Clark & Buckmaster, 2021), and thus hyper-productive; relying on paper mills is one method to sustain that hyper-productivity (Else & Van Noorden, 2021).

- 'Smart' predatory journals or publishers may begin to offer a full package: publication of papers (at a cost) whose content was not human generated, and the possibility of ordering a paper for a price, with or without the possibility of paying for authorship slots; that is, predatory entities doubling as paper mills. The current commercial ghostwriting industry (Chirico & Bramstedt, 2023; Mehregan, 2022; Pérez-Neri et al., 2022) is already very advanced and highly profitable. Unless there is an aggressive campaign to clamp-down on this form of academic fraud, and retract such papers (Rivera & Teixeira da Silva, 2021), science may have finally found its ultimate challenger that could result in its collapse (of trust, integrity, and transparency).
- Even if some journals are able to detect papers derived from paper mills, and discard submissions prior to peer review (Hackett & Kelly, 2022), the authors of such papers will typically suffer no legal challenges or consequences by the rejecting journal, suffering perhaps an ethical slap on the wrist or a warning, and those authors will—with impunity, perhaps even jokingly—resubmit their fraudulent publication to a less fortunate (i.e., not as astute) journal.
- In cases where publications derived from paper mills are detected at the post-publication stage, they may be retracted, but even then, the damage to the integrity of the knowledge stream is done, and permanent, with such fake papers having been cited, sometimes heavily cited (Pérez-Neri et al., 2022). Some authors may leave retracted papers on their *curriculum vitae* in an unretracted status in the hope/expectation that the reader will not check.
- Paper mills may set up fake ORCID accounts that might be used only once to pass the journal's submission requirement of an ORCID for the corresponding author; that is, ghost, single-use or disposable ORCIDs (Kendall et al., 2017; Teixeira da Silva, 2021b). Even though some publishers like Elsevier, Taylor & Francis, and Frontiers have been testing a prototype system to detect paper mill products (Else, 2022), this is far from being an industry-wide response and does not protect the free flow of information across journals' borders, since papers' knowledge sources are linked via references, which might be poorly screened, even by peer reviewers and editors.

The development of generative AI tools and LLMs, such as ChatGPT, will simplify the paper mill industry and those wishing to sell authorships by diversifying their tools of deceit. Some of the ways they may benefit include:

- Papers can be generated much more quickly than was possible before, typically within minutes or hours, rather than weeks or months.
- Generative AI provides for an almost limitless number of papers due to the ample textual permutations that can be generated.
- A command line prompt will likely be used to generate text. This could be automated to ask a generative AI tool to write papers in *batch* mode, that is, a single command is initiated,

producing (at least in theory) hundreds (even thousands) of papers in a matter of hours without any user interaction. In essence, we envision the risk of industrialized scientific fraud.

- Generative AI could be asked to rewrite a paper that is already in the scientific archive but could be used to rephrase sentences or blocks of text (paragraphs) or restructure existing papers. In other words, we envision that it would be possible to use AI to plagiarize a paper but disguise it in such a way that it would pass a plagiarism checker. Even if some text is similar, if it 'copies' from a paper with a CC-BY licence, there might be no ethical repercussion, despite the morally suspect practice.
- It would be possible to translate a paper written in one language and develop an article in another language.
- Once a paper has been generated, a generative AI tool could be asked to rewrite the papers several times, providing paper mills with multiple versions of the same (generated) paper. These versions might be difficult to detect or discern, given that output, for example, by ChatGPT, is inconsistent and varies each time (van Dis et al., 2023), even when the same query is used (Teixeira da Silva & Tsigaris, 2023).
- Given that generative AI makes it easy to write papers, it is a low-cost route to generating journal papers without the need to employ writers, so we can expect to see more paper mills emerge as they will perceive this as a high-value return business model. With the current cost of \$US20 per month to subscribe to the simplest version of GPT-4, the sale of just one milled paper or one authorship could cover the cost of years of ChatGPT investment.
- Single-person paper mills may emerge, given the ease with which papers can be generated.
- Generative AI could be used to manipulate citations (Loan et al., 2022; Mehregan, 2022), for example, in the act of generating papers, AI could be asked to cite papers that it has previously generated. Perhaps it is not sensible to cite papers before they are published but if a generated paper is published, then the AI could be instructed to cite those papers.
- Generative AI could be used to create figures for use in scientific articles. It is already challenging to trace images in papers (Vijayakumar et al., 2023) which are either copied from another paper, or which represents falsified data, but AI-generated images provide a more significant challenge.
- AI could be asked to generate data, which it can then be asked to analyse and then asked to write a paper reporting those results. If this data forms part of the scientific archive, including systematic reviews and meta-analysis, this is potentially (inevitably) very dangerous.

Evidently, this is far from a comprehensive list of the ways in which AI tools like LLMs can be exploited, and more creative ways to utilize these technologies will surely appear in time, including for 'bad' or 'undesirable' ends.⁵

⁵<https://www.nytimes.com/2023/05/01/technology/ai-google-chatbot-engineer-quits-hinton.html> (last accessed: 14 August 2023).

CONCLUSION

With the rapid development of increasingly sophisticated AI tools, legitimate authors can use ChatGPT in many positive ways to help with their writing, including planning the structure of their paper, producing a draft, and correcting grammar. However, that assistance must be acknowledged. When used extensively, the precise text generated by ChatGPT must be indicated, for example as a supplement, to appreciate the relative contributions of AI and human authors. At present, AI tools *on their own* do not have the necessary skills to produce new, meaningful contributions worthy of being recorded in the scientific archive. However, their use by humans threatens to become an abuse, including by authors with few academic skills, or simply dishonest scholars who call themselves 'scientists', but who may be willing to advance their personal and professional agendas, by hook or by crook, including through the use of ChatGPT, to either amplify paper productivity or to reap unfair gains, by gaming the journal metrics and indexing systems that dominate and define the current academic publishing ecosystem. The abuses are not limited to AI- or LLM-generated text and papers, which may become a viable source of income, albeit on the 'black market', via paper mill products, or the sale of authorship positions on ChatGPT-derived texts. We urge the scholarly community (authors, editors, journals, and publishers) to take an immediate tough approach towards the verification of authorship and AI-generated text, before the effects become too widespread to be able to remedy. Publishing already faces serious challenges from predatory publishing, paper mills and authorship commodification, and these threats have now increased immeasurably with the introduction of AI tools and LLMs such as ChatGPT.

AUTHOR CONTRIBUTIONS

The authors contributed equally to the conceptual design, writing, and editing, and took responsibility for the content of the paper.

ACKNOWLEDGEMENTS

We thank Panagiotis Tsigaris (Thompson Rivers University, Canada) for his input and feedback on earlier drafts of this paper.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ARTIFICIAL INTELLIGENCE DECLARATION

No artificial intelligence (AI) tools were used in drafting or writing this paper.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created and analysed in this study.

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