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BEYOND MANIPULATION: OPEN SCIENCE AND THE NEW ERA OF SCIENTIFIC RELIABILITY

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ABSTRACT

Objective: The aim of this provocation was to explore how implementing open science practices can mitigate the harmful practices of p-Hacking and *HARKing* in scientific research, in addition to analyzing the challenges and benefits of this approach for the integrity and reproducibility of studies. **Methods:** A discursive approach was adopted on p-Hacking and *HARKing* practices for exploring open science initiatives. This research studies the topic, analyzing academic articles and reports from scientific institutions. **Main Results:** Open science promotes transparency at all stages of research, reducing p-Hacking and *HARKing*. Pre-registration of studies and open data sharing increase confidence in scientific results and reproducibility. Publishing results, even if negative or non-significant, avoids publication bias, providing a more complete view of the state of the research. These practices reinforce scientific integrity and contribute to a more robust and reliable advancement of knowledge. **Relevance/Originality:** The paper needs more discussions on the integrity and reproducibility of scientific research. Its academic relevance lies in proposing a more transparent and collaborative paradigm for scientific research, promoting greater confidence in scientific findings and contributing more robust knowledge. **Theoretical/Methodological Contributions:** Open science promotes transparency, reducing p-Hacking and *HARKing*. Practices such as prior registration of studies and open sharing of data increase reproducibility. Even if negative, publishing results through a confirmatory approach without exploiting the data avoids publication bias, improves management decisions, and promotes a culture of transparency and reliability in scientific research.

Keywords: Open science, p-Hacking, *HARKing*, Scientific integrity, Reproducibility.

ALÉM DA MANIPULAÇÃO: CIÊNCIA ABERTA E A NOVA ERA DA CONFIABILIDADE CIENTÍFICA

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RESUMO

Objetivo: A pensata teve como objetivo explorar como a implementação de práticas de ciência aberta pode mitigar as práticas prejudiciais de *p-Hacking* e *HARKing* na pesquisa científica, além de analisar os desafios e benefícios dessa abordagem para a integridade e a reprodutibilidade dos estudos. **Método:** Foi adotada uma abordagem discursiva sobre as práticas de *p-Hacking* e *HARKing*, além de explorar as iniciativas da ciência aberta. A pesquisa é uma pensata sobre o tema, analisando tanto artigos acadêmicos quanto relatórios de instituições científicas. **Principais Resultados:** A ciência aberta promove transparência em todas as etapas da pesquisa, reduzindo *p-Hacking* e *HARKing*. O registro prévio de estudos e o compartilhamento aberto de dados aumentam a confiança nos resultados científicos e a reprodutibilidade. A publicação de resultados mesmo que negativos ou não significativos evita o viés de publicação, proporcionando uma visão mais completa do estado da pesquisa. Essas práticas reforçam a integridade científica e contribuem para um avanço mais robusto e confiável do conhecimento. **Relevância / Originalidade:** A pensata insere-se na carência de discussões relacionando a integridade e reprodutibilidade das pesquisas científicas. A relevância acadêmica está na proposta de um paradigma mais transparente e colaborativo para a pesquisa científica, promovendo maior confiança nos achados científicos e contribuindo para a construção de um conhecimento mais robusto. **Contribuições Teóricas / Metodológicas:** A ciência aberta promove transparência, reduzindo *p-Hacking* e *HARKing*. Práticas como registro prévio de estudos e compartilhamento aberto de dados aumentam a reprodutibilidade. Publicar resultados mesmo que negativos, numa abordagem confirmatória, sem explorar os dados, evita viés de publicação, melhorando decisões gerenciais e promovendo a cultura de transparência e confiabilidade na pesquisa científica.

Palavras-chave: Ciência aberta, *p-Hacking*, *HARKing*, Integridade científica. Reprodutibilidade.

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INTRODUCTION

The integrity and replicability of scientific research have been the subject of growing concern in the academic community. The prevalence of practices such as *p-Hacking*, which involves manipulating the data until statistically significant results are achieved, and *HARKing*, which entails formulating hypotheses after the results are known, has undermined confidence in scientific findings (Head et al., 2015; Yamada, 2018). These practices not only compromise the quality of research but also hinder the construction of scientific knowledge, which is essential for the progress of international business and related areas of strategic management, marketing, and innovation.

These challenges are especially relevant in the humanities and applied humanities, which belong to the domain of soft sciences. In these areas, scientific confirmation faces additional difficulties because of the complexity of the phenomena studied and the influence of contextual and subjective factors, which make it difficult to replicate results and apply strictly controlled methods, such as in the hard sciences. The subjectivity inherent to soft sciences often requires interpretative approaches, expanding the possibilities of scientific manipulation by reinforcing the need for practices such as those proposed by open science. Recognizing these characteristics is essential to adapt strategies that promote research integrity and reliability.

Implementing open science practices is a potential solution to mitigate these problems. Open science promotes transparency at every stage of the research process, from planning to publication of results (Martins & Mendes-da-Silva, 2024). Among the most prominent initiatives are the open sharing of data, the prior registration of studies, and the publication of results, even if negative, through a confirmatory approach. These practices aim to increase the reliability of studies and foster collaboration and independent verification of results, strengthening the robustness of science (Spiegelman, 2021).

This provocation's target audience includes researchers, academics, scientific professionals, and managers of research institutions, as well as graduate students and other individuals involved in the scientific production process. Adopting open science practices is particularly relevant for these groups, as it offers tools that can significantly improve the quality and credibility of their research. This provocation provides a comprehensive overview of the benefits and challenges of implementing open science and offers practical guidelines for its application.

The central question to be explored is how implementing open science practices can mitigate the harmful practices of *p-Hacking* and *HARKing* in scientific research, in addition to analyzing the challenges and benefits of this approach for the integrity and reproducibility of studies. Open science proposes a more transparent and collaborative research paradigm, which can correct the lack of reproducibility and increase trust in scientific results. However, its adoption faces significant challenges, such as cultural resistance among researchers and the need for an adequate technological infrastructure. This provocation explores these dynamics, arguing that despite the obstacles, the long-term benefits of open science are essential for promoting a more rigorous and reliable science (Bergkvist, 2020).

1. *P-HACKING*: CHALLENGES AND SOLUTIONS FOR THE INTEGRITY OF SCIENTIFIC RESEARCH

p-Hacking, or p-value manipulation, represents a practice that profoundly compromises the integrity of scientific research. It involves manipulating the data and analytical methods until statistically significant results are obtained, usually a p-value of less than 0.05 (Wicherts, 2021). This practice distorts scientific findings and puts the credibility of science at risk (Hu et al., 2023). Common examples of *p-Hacking* include selective exclusion of data, performing multiple statistical analyses without adequate correction for multiple comparisons, and reformulating hypotheses after the initial data analysis. Such actions violate the principles of rigorous statistical analysis and often lead to the publication of spurious results (McCloskey & Michaillat, 2024).

The impacts of *p-Hacking* on scientific research are numerous and harmful. First, *p-Hacking* results in many false positives that cannot be replicated, undermining trust in the scientific literature and compromising the scientific knowledge base (Stefan & Schönbrodt, 2023; Stengelin et al., 2024). Second, the *p-Hacking* contributes to publication bias, i.e., studies with significant results are more likely to be published, while negative or non-significant results are

often ignored. This bias creates a distorted view of scientific reality, promoting only some possible outcomes. In addition, the time and resources invested in trying to replicate or base new studies on unreliable findings result in a significant waste, slowing scientific advancements and diverting efforts from more promising research (Hudson, 2021). Finally, the *p-Hacking* represents a violation of the fundamental ethical principles of scientific research, such as honesty and transparency, and the prevalence of this practice can diminish public trust in science and scientists (Fraser et al., 2018).

Several strategies can be adopted to combat *p-Hacking*. Prior registration of studies is one of the most effective ways to prevent this practice. By recording the hypotheses, methods, and analysis plans before data collection, researchers commit to a pre-established plan, reducing the flexibility to manipulate analyses later (Hitzig & Stegenga, 2020). Platforms such as the Open Science Framework (OSF, 2024) facilitate this process by promoting transparency and integrity. In addition, sharing the raw data and analysis codes used in the studies allows other researchers to verify the results and perform independent analyses, increasing the transparency and reproducibility of the research. Educating researchers about good statistical analysis practices and the dangers of *p-Hacking* is also fundamental. Training programs in statistical methods and research ethics can sensitize and equip scientists to conduct more rigorous analyses.

Another essential strategy to alleviate the pressure for positive results is to promote the publication of negative or non-significant outcomes. Scientific journals and funding agencies can fundamentally appreciate scientific contributions, regardless of the p-value. One way to achieve this is by shifting the focus from statistical analyses centered on null hypothesis testing to one that emphasizes effect sizes with confidence intervals. Prioritizing effect sizes instead of statistical significance provides a more informative measure of the findings' magnitude. Confidence intervals, rather than p-values, should be utilized as the primary analytical tool for estimating measurement accuracy. Enhancing statistical education diminishes the emphasis on significant results while promoting more robust and reliable analyses, thereby reducing the occurrence of p-hacking.

The fight against *p-hacking* is essential for maintaining integrity and trust in scientific research. Implementing transparency practices, promoting ongoing education, and valuing the publication of all results are key steps to ensure that science advances ethically and reliably. Eliminating p-hacking strengthens the robustness of scientific conclusions by ensuring that results are derived from transparent, unbiased, and replicable methodologies rather than manipulated data analysis.

2. *HARKING*: IMPACTS AND STRATEGIES TO PRESERVE SCIENTIFIC INTEGRITY

HARKing, an acronym for hypothesizing after the results are known (formulation of hypotheses after the results are known), is a practice that significantly compromises the integrity of scientific research (Prosperi et al., 2019). It involves formulating hypotheses only after the data analysis and presenting them as predefined. While it may seem harmless for mining data, *HARKing* distorts the scientific narrative and undermines trust in research.

HARKing occurs when researchers adjust their hypotheses to align with the results, creating a false impression of predictability and scientific rigor. This practice deceives reviewers, readers, and other researchers by presenting a relationship that seems confirmed by the data when it is later discovered. Instead of following a genuine scientific process in which hypotheses are rigorously tested, *HARKing* subverts this process, compromising the credibility of scientific findings.

The impacts of *HARKing* on scientific research are varied and profound. First, this practice reduces confidence in the scientific literature since the results presented as predictable may be mere products of data exploration without a solid theoretical basis. It generates a body of scientific knowledge inflated by results that seem more robust than they are. Second, *HARKing* contributes to confirmation bias, i.e., only hypotheses that fit the data are reported, ignoring other possibilities that could be equally or more plausible. In addition, *HARKing* can lead to a waste of resources, as other researchers may base their studies on hypotheses that have not been rigorously tested, leading to fruitless efforts in trying to replicate or expand on these findings. Finally, *HARKing* represents

a violation of the ethical principles of scientific research, such as honesty and transparency, compromising the integrity of science and the public's trust.

Several strategies can be implemented to combat *HARKing* besides *p-hacking*. One of the most effective is the prior registration of studies (Munafò et al., 2017). By pre-recording hypotheses and analysis methods, researchers follow an established plan before data analysis, reducing the temptation to adjust hypotheses later. In addition, transparency in the publication of methods and analyses is fundamental. Detailing the study steps and exploratory analyses allows other researchers to understand the full context of the results, differentiating between confirmatory and exploratory hypotheses.

Ongoing education and training are also essential to combat *HARKing*. Programs that teach good research practices, scientific ethics, statistical literacy, versioning technologies, and control of computational environments can sensitize researchers to the dangers of *HARKing* and equip them to conduct more rigorous analyses. In addition, encouraging the publication of exploratory studies can help reduce the pressure for confirmatory results. Scientific journals and funding agencies can play an essential role in valuing all scientific contributions and recognizing the importance of both confirmatory and exploratory studies, as well as both positive and negative results.

Statistical literacy and the training of qualified teachers in *data skills* are among the most essential requirements for changing the scientific culture to value the reproducibility of research (McAleer et al., 2022). Information technology tools should be promoted within the OSFs, such as software versioning and environment control, statistical approaches focused on effect sizes, confidence intervals, and Bayesian analyses (Brei, 2022). Fighting the *HARKing* is critical to maintaining integrity and trust in scientific research. Implementing transparency practices, promoting continuous education, and valuing the publication of all results are fundamental steps to ensure that science advances ethically and reliably.

3. *P-HACKING* AND *HARKING* IN THE CONTEXT OF INTERNATIONAL BUSINESS: IMPACTS ON STRATEGIC MANAGEMENT, MARKETING, AND INNOVATION

While generally associated with scientific research, the practices of *p-hacking* and *HARKing* have significant implications for international business and related areas of strategic management, marketing, and innovation (Brodeur et al., 2024). These practices compromise the integrity of data and analytics, leading to poor business decisions, strategies, ineffective marketing, and flawed innovation initiatives.

In the field of international business, the accuracy and reliability of data are key to strategic decision-making. *P-Hacking*, which involves manipulating data to achieve desired outcomes, can lead to biased analyses that do not reflect market reality (Fišar et al., 2024). For example, a company that manipulates data to show a market performance superior to the actual one may make expansion decisions based on inaccurate information, resulting in misdirected investments and loss of resources. Similarly, *HARKing*, by allowing the formulation of hypotheses after obtaining the results, can distort the perception of market trends and lead to inappropriate business strategies.

In strategic management, the practices of *p-Hacking* and *HARKing* can compromise the development of long-term plans and the allocation of resources (Gupta & Bosco, 2023). Strategies based on manipulated data or hypotheses adjusted to the observed results may seem promising in the short term but are unsustainable in the long term. Reliance on biased analyses can result in an inappropriate allocation of resources, i.e., areas needing investments are neglected in favor of more profitable projects due to the manipulated data, leading to inconsistent organizational performance and harming the company's competitiveness in the global market.

In marketing, data integrity is essential for understanding consumer preferences and behaviors. *P-hacking* can skew market research results by suggesting that specific marketing campaigns or products are more effective than they are. This can lead to failed product launches or ineffective advertising campaigns that fail to capture the target audience's attention. Similarly, *HARKing* can result in *marketing* strategies based on superficial or fine-tuned insights that do not reflect consumers' actual needs or desires, compromising the effectiveness of marketing initiatives.

In innovation, *p-hacking* and *HARKing* can have dire consequences. Innovation depends on exploring new ideas and rigorously validating hypotheses to develop disruptive products and services. Manipulating data to

show success where there is none or adjusting hypotheses to fit the results can lead to product launches that fail in the market, waste of resources on unviable projects, and a culture of innovation that values quick results over sustainable research and development and can harm not only the company's ability to innovate but also its reputation in the market.

To mitigate the impacts of *p-Hacking* and *HARKing* on international business, strategic management, marketing, and innovation, it is essential to promote integrity and transparency practices in data analyses. Implementing strict policies for pre-recording hypotheses and methods can help ensure that studies are conducted honestly and based on assumptions established before data collection. Additionally, encouraging transparency in the presentation of results, including the publication of raw data and analysis methods, can allow others to review and verify the results, increasing confidence in decisions based on that data. Educating executives and analysts on data analytics best practices and the importance of research integrity is equally relevant. Training and continuous development programs can sensitize professionals to the dangers of *p-Hacking* and *HARKing*, equipping them with the necessary skills to conduct rigorous and ethical analyses.

Finally, promoting an organizational culture that prioritizes transparency and integrity over the pursuit of quick results can help prevent the temptation to manipulate data or adjust hypotheses. Recognizing and rewarding robust and transparent analysis practices can contribute to a more reliable database and more informed decision-making even when the results are not positive.

4. INTEGRATION OF *P-HACKING*, *HARKING,* AND OPEN SCIENCE: OPPORTUNITIES, CHALLENGES, AND DIFFICULTIES

Science faces challenges regarding integrity and reliability because of practices, such as *p-hacking* and *HARKing*. Both compromise the validity of scientific findings, creating a literature inflated by false positives and irreproducible results. Open science is a promising solution to combat these harmful practices, promoting greater transparency and reproducibility (Limongi, 2024). However, its implementation faces several opportunities, challenges, and difficulties.

In emerging countries, the pressure for publications in high-impact journals is intensified by the need for international recognition and access to limited resources. This pressure can lead researchers to adopt questionable practices, such as *p-hacking* and *HARKing*, to search for meaningful results that increase your chances of publication (Brodeur et al., 2020). In addition, limited infrastructure and restricted access to quality data can hinder the implementation of open science practices, amplifying these challenges.

In the context of international business, the complexity and variability of global markets make the replicability of studies more challenging. Factors such as cultural, economic, and regulatory differences can influence the results by increasing the manipulation of hypotheses and data to obtain publishable results (Rubin, 2017). Adopting open science practices in this field faces additional obstacles, such as protecting confidential information and competition between companies, which can limit transparency and data sharing (Kerr, 1998). Therefore, it is essential to develop strategies adapted to specific contexts, promoting scientific integrity and transparency while considering the particularities and challenges faced by researchers in emerging countries and the area of international business.

Open science provides opportunities to mitigate the practices of *p-Hacking* and *HARKing*. Transparency is one of the main pillars of open science, encouraging researchers to share data, methods, and results in an open and accessible way (Isager et al., 2024). Several platforms facilitate the prior registration of studies, in which hypotheses and methods are recorded before data collection, reducing the possibility of subsequent manipulation. This practice increases confidence in published results and promotes collaboration and independent verification of studies, which are essential for scientific robustness. In addition, open data sharing allows other researchers to replicate studies, increasing the reproducibility and reliability of scientific research. Encouraged by open science, the publication of negative or non-significant results also contributes to a more complete and honest view of scientific reality, reducing the publication bias that favors positive results.

However, the implementation of open science is not without its challenges (Allen & Mehler, 2019). Cultural resistance is one of the biggest obstacles.

Many researchers are used to working in a system that primarily values positive results and publications in high-impact journals, which can discourage adopting open practices. In addition, legitimate concerns about intellectual property and misuse of openly shared data exist. Protecting researchers' rights while promoting transparency is a delicate balance that must be carefully managed. Another challenge is the need for an adequate technological infrastructure to support open science. Data repositories, pre-registration platforms, and transparent analysis tools require investments in technology and training. Without adequate institutional and financial support, many researchers may find it challenging to adopt these practices fully. In addition, the shift to open science requires re-evaluating academic incentives.

Currently, reward systems in academia often favor the quantity of publications and the immediate impact of the results rather than long-term quality and reproducibility. Thus, the editors of high-impact journals also play a central role in promoting change. As direct influencers of publication demands, it is up to these editors to value transparency and reproducibility practices and lead the movement for new editorial standards that prioritize scientific integrity (Limongi & Marcolin, 2024). The adoption of policies such as the requirement of prior registrations, the publication of open data, and the acceptance of negative results in top journals not only encourages researchers to employ more rigorous practices, but it would also set an example for other scientific journals by promoting a broader cultural transformation in the academic system. Sheets (2024) emphasizes the importance of sharing negative results for more transparent and reproducible science. Conferences such as the Society for Experimental Psychologists, the International Metascience, and open research practices conferences encourage the submission of studies with null results, promoting discussions on replicability and transparency. Additionally, platforms such as the *Journal of Articles in Support of the Null Hypothesis* and the *Journal of Negative Results* are dedicated to publishing research with non-significant results, providing researchers with appropriate channels to share their findings. Therefore, reforming these systems to value transparency, collaboration, and reproducibility is critical to the widespread adoption of open science.

The practical difficulties cannot be underestimated either; implementing rigorous prior records and sharing raw data can be complex and require additional time from researchers. The need to educate and train researchers on open science practices and statistical literacy also represents a significant effort in terms of resources and time. Despite these challenges, the opportunities offered by open science to combat *p-Hacking* and *HARKing* are substantial. By fostering a culture of transparency and collaboration, open science can transform how research is conducted, increasing the integrity and reliability of scientific results. For this to occur, a joint effort is needed from the scientific community, research institutions, funding agencies, and scientific journals.

In this sense, recently published studies such as the work of Brodeur et al. (2024) have critically analyzed the role of scientific journals in mitigating practices, such as *p-Hacking* and *HARKing*. These studies highlight that, although some editorial initiatives have been adopted, such as the requirement of prior registrations and the promotion of transparency in methods, the changes are still restricted to declarative policies or specific journals without a broad transformation in the publication system. In addition, Ferguson et al. (2023) reported that while most editors recognize the importance of open practices, the implementation of concrete measures, such as encouraging the publication of negative results, is still limited. This gap between the propositions of greater transparency and the effective change in editorial demands reflects the need for a more active commitment from top journal editors to lead these transformations.

In this way, integrating open science practices to mitigate *p-Hacking* and *HARKing* offers a promising path for improving scientific research. While significant challenges exist, the opportunities to increase transparency, reproducibility, and trust in scientific findings justify the efforts. The widespread and effective adoption of open science can create a more honest and robust research environment, benefiting science and society.

5. IMPLICATIONS

Implementing open science practices has profound implications for the integrity and reliability of scientif-

ic research. Practices such as *p-hacking* and *HARKing* undermine trust in scientific findings and compromise the construction of knowledge in several areas, including international business, strategic management, marketing, and innovation. Open science is a promising solution to mitigate these problems, promoting more transparent and reliable science.

Open science is based on principles that aim to increase transparency at all stages of the research process, from planning to publication of results. Still, the pressure for positive results and publications in high-impact journals is particularly intense for early-career researchers, such as graduate students, who often rely on these publications to advance their academic careers. The requirement for quantitative productivity, usually imposed by graduate programs and funding criteria, creates an environment where *p-Hacking* and *HARKing* can be seen as tempting alternatives to achieve publishable results. This dynamic undermines scientific integrity and puts researchers in an ethical and psychological dilemma, compromising the quality of academic work and generating emotional exhaustion. Recognizing and addressing this issue is key to creating an academic system that values quality and transparency over the quantity of publications, promoting a more sustainable and ethical environment for scientific research.

Among the most prominent practices of open science that should be included from the beginning of the orientation or of a new research project are the open sharing of data, the prior registration of studies, and the publication of confirmatory results, even if negative. Data sharing allows other researchers to access, analyze, and replicate the data used in a study, increasing transparency and facilitating independent verification of results. This practice is key to preventing *p-Hacking* and *HARKing*, establishing the hypotheses and methods before the results are known. Several tools can contribute to this registry by promoting the integrity and reproducibility of research. In addition, the publication of confirmatory results, even if negative or non-significant, is essential for a complete and honest view of the state of research in a given area, thus avoiding publication bias, which favors only positive results.

The adoption of open science practices has the potential to transform scientific research, promoting more transparent, collaborative, and trustworthy science. Overcoming cultural and technological challenges requires a joint effort by the scientific community, research institutions, funding agencies, and scientific journals. Successful implementation of these practices will increase the integrity and reliability of scientific results and benefit society by promoting a more ethical and robust advancement of scientific knowledge.

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