Comment

Comment on Cárdenas-García, J.F. Info-Autopoiesis and the Limits of Artificial General Intelligence. *Computers* 2023, *12*, 102

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1. Introduction

In the article by Jaime F. Cárdenas-García [1], the background establishes a need to re-evaluate the ambitious projections about artificial intelligence (AI), particularly artificial general intelligence (AGI), given the current technological limitations and societal implications. The author's aim is to introduce "info-autopoiesis" as a novel framework to better understand and predict the development limits of AI and AGI. This concept is explored as a self-referential, recursive process essential for generating and managing information, positioned as fundamental to both human and artificial cognition. The relevance of this work to the current state of the art in AI research lies in its critique of overoptimistic AI predictions and its potential to ground future AI developments in a more empirically supported framework, thus aligning technological advancements with a deeper understanding of human intelligence mechanisms. This could foster more realistic expectations and responsible development in AI fields.

2. Critical Analysis

2.1. Major Contributions

The article makes significant contributions to the discourse on artificial intelligence by challenging the prevailing optimism surrounding AGI. The "info-autopoiesis" framework is articulated as a fundamental process for the self-production of information, drawing parallels between human cognitive processes and potential artificial systems. Cárdenas-García's work rigorously scrutinizes the existing assumptions about the capabilities of AI systems, suggesting that without a solid understanding of the recursive and self-referential nature of human intelligence, attempts at replicating such a process in machines may be fundamentally flawed. The introduction of info-autopoiesis offers a fresh perspective on the limitations and potential pathways for the development of AGI, marking a pivotal shift from a purely technological focus to one that incorporates insights from biological and informational sciences. This reorientation may guide future AI research towards more sustainable and ethically aware practices, addressing both the technical and societal challenges posed by advanced AI systems.

2.2. Methodological Review

The core concept of info-autopoiesis draws heavily from biological systems, attempting to apply this self-referential system of information production to AGI. While this interdisciplinary approach is intellectually stimulating, it faces the fundamental challenge of replicating biological processes in computational systems. Biological systems and computational systems function under different operational and developmental paradigms. The assumption that insights from biology directly translate to AGI without substantial adaptation may oversimplify the complex and unique challenges inherent in computational systems. The methodology relies predominantly on philosophical argumentation and theoretical extrapolation rather than empirical data. While theoretical contributions are valuable, the absence of empirical testing or computational modeling to support the

claims makes the framework speculative. For the concept of info-autopoiesis to gain broader acceptance and utility within AI research, it would benefit from rigorous empirical studies that validate its applicability and effectiveness in the development of AGI. The article occasionally suffers from a lack of clear operational definitions for key terms like "info-autopoiesis". The complex nature of the discussion sometimes obscures the practical implications of the framework for AI development. Without clear definitions and demonstrable applications, it becomes challenging for other researchers to apply or test the proposed framework in their own work, limiting its potential impact. While it is prudent to acknowledge and explore the limitations of current AI technologies, the focus on what AI cannot currently achieve might detract from exploring potential capabilities and areas in which AI could realistically be expected to evolve in the near future. This perspective, while providing a necessary counterpoint to overly optimistic projections, might also hinder the exploration of feasible advancements in AGI. The article positions info-autopoiesis outside mainstream AI research, which primarily focuses on advancements in machine learning, neural networks, and cognitive architectures. There is a gap in the integration of the proposed framework with existing AI methodologies, which may make it challenging for the framework to influence or be adopted by the broader AI research community. Bridging this gap with more detailed discussions of how info-autopoiesis can directly influence current AI development practices would strengthen the framework's relevance.

2.3. Comparative Analysis

The article by Jaime F. Cárdenas-García diverges significantly from conventional AI research, which primarily leverages computational and statistical models to advance AGI. Most contemporary studies in AGI, such as those by DeepMind or OpenAI, focus on the capabilities of deep learning networks and reinforcement learning to mimic and potentially surpass human cognitive abilities. These studies [2,3] emphasize the potential of AI systems to achieve human-like performance across a broad spectrum of tasks through the accumulation and processing of large datasets. In contrast, Cárdenas-García's framework draws from biological and informational sciences to suggest that understanding the self-referential and recursive nature of information processing in biological systems is crucial for the development of true AGI. This theoretical approach critiques the current AI methodologies for their lack of a fundamental understanding of how intelligence naturally develops and operates. While mainstream AI research optimistically pushes the boundaries of what machines can achieve, Cárdenas-García calls for a reevaluation of these boundaries through the lens of natural information processing, positioning his claims within a more cautious and potentially more ethically aware framework. This contrast highlights a fundamental schism in AI research between advancing current technologies and fundamentally understanding the nature of intelligence, whether artificial or natural [4].

Relating the concept of info-autopoiesis to Marxian Alienation Theory offers a novel lens through which to examine the evolving relationship between humans and technology, particularly the potential existential threats and societal disruptions posed by AI and machine learning (AIM). Info-autopoiesis, emphasizing the self-referential and recursive processing of information akin to biological systems, contrasts sharply with the alienation experienced by workers as posited by Marx, where individuals become estranged from the products of their labor due to the mechanization and commoditization of work [5]. The integration of such AI systems could exacerbate these forms of alienation, as machines potentially supplant human roles, leading to an identity and purpose crisis among the workforce [6]. The ex post facto research methodology and Derrida's framework of deconstruction and reconstruction [7] provide a robust analytical approach to dissecting the political narratives surrounding AI, particularly the varied degrees of urgency and alarm with which American politicians address the potential for AIMs to disrupt job markets [6]. By evaluating the rhetoric and motivations behind these political positions, one can assess the extent to which the discourse may be leveraged for electoral gain rather than addressing the substantive socio-economic implications of AI development and integration into soci-

ety [6]. This approach underscores the necessity of a politicized but informed discourse that genuinely addresses the human-centric issues at the heart of technological advancement, ensuring that predictions about AIMs and their impacts on jobs are critically examined and ethically considered.

2.4. Analysis of Findings

The implications of Jaime F. Cárdenas-García's article on "info-autopoiesis" and the limits of AGI are profound and multifaceted, particularly in the realms of AI development and the ethical considerations of technology's role in society. By introducing the concept of info-autopoiesis, which posits that understanding the recursive and self-referential mechanisms of human intelligence is crucial for developing effective AGI, the article challenges the prevailing methodologies in AI research that largely focus on algorithmic efficiency and data processing capabilities. If Cárdenas-García's theoretical framework is validated and adopted, it could lead to a paradigm shift in how AI researchers approach the creation of intelligent systems, emphasizing a bio-inspired approach that may align more closely with natural cognitive processes. This shift could potentially lead to more robust AI systems that embody a deeper understanding of human-like learning and decision-making processes. The emphasis on the limitations and ethical considerations of AI underscores the need for a cautious approach to the deployment of AI technologies, particularly those purporting to achieve or mimic human intelligence. By articulating these limitations, the article contributes to the ongoing discourse on the responsible development of AI, advocating for more transparency, safety, and governance in AI research and applications. This perspective is increasingly relevant as society grapples with the rapid advancement and integration of AI technologies in critical sectors.

2.5. Suggested Modifications

To enhance the theoretical framework of info-autopoiesis proposed by Jaime F. Cárdenas-García and its applicability in the field of AGI, specific modifications and extensions could be beneficial. Firstly, integrating empirical research methodologies, such as computational modeling or simulations that mimic biological information processes, could provide quantitative support for the theory and help validate its practical implications for AGI development [8]. This empirical approach would not only bridge the gap between theory and application but also allow for iterative refinement of the info-autopoiesis concept based on experimental outcomes. Extending the framework to include a comparative analysis with existing cognitive architectures in AI could reveal overlaps and divergences that might refine the implementation of bio-inspired processes in machine learning environments [9,10]. Another productive extension would involve interdisciplinary collaboration, incorporating insights from neuroscience, cognitive science, and systems biology, to deepen the understanding of self-referential and recursive processes in both biological and artificial systems [11]. Such collaboration could foster a more holistic approach to AI development, ensuring that the systems developed are not only technically proficient but also aligned with the fundamental principles of natural intelligence processes. These modifications and extensions would not only strengthen the theoretical underpinnings of info-autopoiesis but also enhance its relevance and applicability in the pursuit of truly intelligent machines.

3. Conclusions

3.1. Implications for the Field

The insights from Jaime F. Cárdenas-García's article touch on broader multidisciplinary concerns, notably bridging the gaps between AI, cognitive science, ethics, and philosophy. By proposing that AGI development should consider the self-referential and recursive nature of human intelligence, as observed in biological systems, the framework pushes for a deeper integration of biological and cognitive sciences into AI research [12]. This integrative approach encourages a more holistic view of intelligence, potentially leading to AGI systems that better mimic human cognitive processes and decision-making [13].

The emphasis on understanding the inherent limitations of AI systems speaks directly to ethical concerns regarding the deployment and control of AI technologies [14,15]. Ethicists and AI developers may find common ground in the pursuit of technologies that are not only effective but are also aligned with societal values and human well-being [15]. By highlighting the gaps in current AI capabilities, the article invites philosophical inquiry into the nature of intelligence, consciousness, and the role of machines in society [16]. These considerations could influence policy-making, particularly regarding how AI technologies are regulated and integrated into critical areas such as healthcare, security, and education [14]. Thus, the article's insights encourage a convergence of disciplines, fostering a conversation that could lead to more responsible and innovative approaches to both the development and governance of AI.

3.2. Future Directions

Building on the findings of Jaime F. Cárdenas-García's article on info-autopoiesis and its implications for AGI, several areas for further research emerge as critical for advancing the theory and its practical application. Firstly, rigorous empirical testing through the development of computational models that simulate info-autopoietic processes can provide quantitative backing and potentially uncover new dimensions of the theory. This could involve creating AI systems that incorporate recursive feedback loops and self-referential processing capabilities, modeled after biological systems, to observe their impact on learning and decision-making in complex environments. Secondly, interdisciplinary studies combining insights from neurobiology, cognitive psychology, and information theory could enrich our understanding of how info-autopoiesis might be realized in both natural and artificial systems. Such studies could help in the identification of specific biological processes that could be emulated in AI systems to enhance their autonomy and adaptability. Thirdly, exploring the ethical and societal implications of AI systems designed around the info-autopoietic framework would be vital. This research could focus on the consequences of deploying such AI systems in various sectors, examining issues such as transparency, predictability, and controllability. Finally, comparative studies that evaluate the performance and outcomes of info-autopoietic AI systems against those developed using traditional AI approaches could highlight strengths, weaknesses, and areas for improvement, providing a clearer direction for future AI development strategies. These areas of further research would not only clarify and extend the original article's findings but also contribute to a more nuanced and robust framework for the development of AGI.

Conflicts of Interest: The author declares no conflicts of interest.

References

1. Cárdenas-García, J.F. Info-Autopoiesis and the Limits of Artificial General Intelligence. *Computers* **2023**, *12*, 102. [CrossRef]
2. Morris, M.R.; Sohl-Dickstein, J.; Fiedel, N.; Warkentin, T.; Dafoe, A.; Faust, A.; Farabet, C.; Legg, S. Levels of AGI for Operationalizing Progress on the Path to AGI. *arXiv* **2023**, arXiv:2311.02462. [CrossRef]
3. Achiam, J.; Adler, S.; Agarwal, S.; Ahmad, L.; Akkaya, I.; Aleman, F.L.; Almeida, D.; Altenschmidt, J.; Altman, S.; Anadkat, S.; et al. GPT-4 Technical Report. *arXiv* **2023**, arXiv:2303.08774. [CrossRef]
4. Mikkilineni, R.V. Infusing Autopoietic and Cognitive Behaviors into Digital Automata to Improve Their Sentience, Resilience, and Intelligence. *Big Data Cogn. Comput.* **2021**, *6*, 7. [CrossRef]
5. Mingers, J. Autopoiesis and Marxian Alienation Theory. *Int. J. Gen. Syst.* **1995**, *21*, 229–236. [CrossRef]
6. Wogu, I.A.; Misra, S.; Assibong, P.A.; Adewumi, A.; Damaševičius, R.; Maskeliūnas, R. A Critical Review of the Politics of Artificial Intelligent Machines, Alienation and the Existential Risk Threat to America's Labour Force. *J. Oper. Res. Soc.* **2018**, *10963*, 217–232. [CrossRef]
7. Derrida, J. Deconstruction and the other: An interview with Richard Kearney. In *Dialogues with Contemporary Continental Thinkers*; Manchester University Press: Manchester, UK, 1984; pp. 107–126.
8. Walsh, T. Empirical Methods in AI. *AI Mag.* **1998**, *19*, 121–124. [CrossRef]
9. Langley, P. Cognitive Architectures and General Intelligent Systems. *AI Mag.* **2006**, *27*, 33–44. [CrossRef]
10. Dehaene, S.; Dudai, Y.; Konen, C.S. Cognitive Architectures. *Neuron* **2015**, *88*, 1. [CrossRef] [PubMed]

11.   Houpt, J.W.; Heathcote, A.; Eidels, A. Bayesian Analyses of Cognitive Architecture. *Psychol. Methods* **2017**, *22*, 288–303. [CrossRef] [PubMed]

12.   Hassoun, S.; Jefferson, F.; Shi, X.; Stucky, B.J.; Wang, J.; Rosa, E. Artificial Intelligence for Biology. *Integr. Comp. Biol.* **2021**, *61*, 2267–2275. [CrossRef] [PubMed]

13.   Romero, O.J.; Zimmerman, J.; Steinfeld, A.; Tomasic, A. Synergistic Integration of Large Language Models and Cognitive Architectures for Robust AI: An Exploratory Analysis. *arXiv* **2023**, arXiv:2308.09830. [CrossRef]

14.   Ienca, M.; Fins, J.; Jox, R.; Jotterand, F.; Voeneky, S.; Andorno, R.; Ball, T.; Castelluccia, C.; Chavarriaga, R.; Chneiweiss, H.; et al. Towards a Governance Framework for Brain Data. *Neuroethics* **2021**, *15*, 20. [CrossRef]

15.   Jaiswal, R.K.; Sharma, S.S.; Kaushik, R. Ethics in AI and machine learning. *J. Nonlinear Anal. Optim.* **2023**, *14*, 8–12. [CrossRef]

16.   Zhang, Y. A Historical Interaction between Artificial Intelligence and Philosophy. *arXiv* **2022**, arXiv:2208.04148. [CrossRef]