Reply

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

Jaime F. Cárdenas-García ⓘD

Department of Mechanical Engineering, University of Maryland, Baltimore County, 1000 Hilltop Circle, Baltimore, MD 21250, USA; jfcg@umbc.edu

1. Introduction

The author thanks and acknowledges the many positive and critical comments by Robertas Damaševičius [1] in his efforts to perform a thorough appraisal of Cárdenas-García [2]. This response discusses these comments to, in some instances, clarify the text of the article, and, in others, offer something further to consider.

Since the Comment consists of nine paragraphs, each paragraph will be addressed in the order in which it appears, referring to specific parts in each paragraph. The numbering of References in the original Comment has been omitted so as not to confuse them with the newly added numbered References.

2. Paragraph 1

Damaševičius states, when referring to info-autopoiesis, "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". Cognition is a complex word of which the meaning and use might lead to confusion, reason for which the word cognition is not used in the paper. What is common to both humans and artificial creations by humans is information. Semantic and syntactic information are info-autopoietic creations by humans. The artificial creation of syntactic information by humans leads to the invention of computers in which software generates other syntactic creations ad infinitum. However, no matter the sophistication of these artificial syntactic creations, they are unable to produce semantic information. Therefore, the process of info-autopoiesis or information self-creation is fundamental only to humans.

3. Paragraph 2

As noted very clearly by Damaševičius, one of the goals of the article is to challenge "the prevailing optimism surrounding AGI" using info-autopoiesis as a basis. Indeed, none of the references cited in the paper under discussion base their optimism or pessimism regarding AGI on anything other than personal opinions. Additionally, the main approach taken to resolving AGI is by means of computational resources that tend to grow qualitatively and quantitatively. Info-autopoiesis is proposed to assess the prospects for AGI development considering "insights from biological and informational sciences". Such an assessment might help rethink how future resources might be better deployed to achieve the goals that humanity sets itself in the field of AI.

However, the notion of disregarding biological aspects of human intelligence by AI researchers is worth revisiting. The advent of neural networks is certainly an attempt at considering the perceived biological aspects of human intelligence [3]. Also, recent papers by Yann LeCun [4,5] show instances of considering biological aspects of human intelligence as relevant to defining the architecture germane to AGI. Figure 1 shows the perceived interconnected modular structure of an autonomous AI on which developments toward

AGI are based [4]. To invite a comparison, Figure 2 depicts the human organism in its environment used to pose the process of info-autopoiesis [2]. No attempt is made here to describe the workings of these figures in detail. For that the reader is referred to the cited references. Both figures convey the same general relationship that exists between a human actor (organism) and its environment. The main ultimate difference between these two ways of looking at the problem is that LeCun can devise some very creative ways, still in the process of development, to solve the problem of AI that he poses. LeCun believes that it is a matter of time (10 years) before AGI is achieved using "world modeling" [6]. On the other hand, Cárdenas-García [2], using the info-autopoiesis framework, deems that the problem defined as AGI is not achievable, no matter the effort, arguing that this non-achievable realization should lead to the development of some very interesting applications in AI while pursuing goals that are more in line with this awareness, limiting the resources used in the pursuit of ambitious unachievable AGI projects.
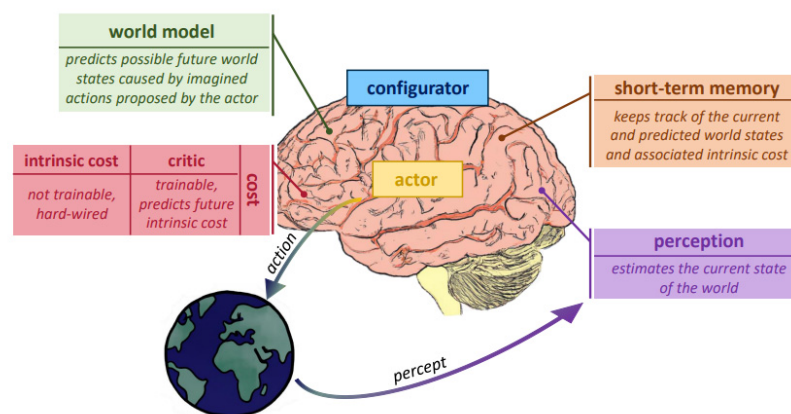

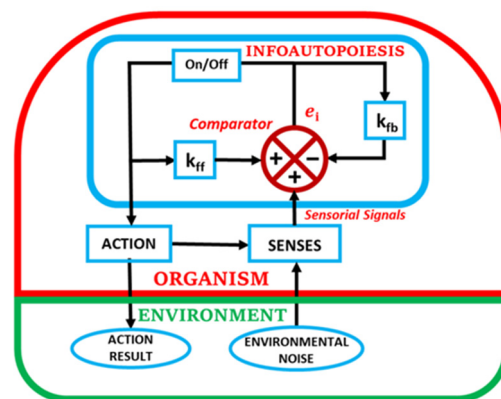**Figure 1.** The modular structure of autonomous AI (from [4]).

Figure 2. The human organism in its environment and info-autopoiesis (from [2]).

4. Paragraph 3

Robertas Damaševičius poses "several potential weaknesses and discrepancies in the methodology" of info-autopoiesis. Let us examine each one in turn to clarify the key aspects of info-autopoiesis.

As noted above, the process of info-autopoiesis or information self-creation is fundamental only to humans. There is no attempt to use or apply info-autopoiesis to AGI, except to show that AGI is not achievable. Therefore, there is no attempt at "analogizing biological processes to computational systems". The production of semantic information is unique to living beings. There is no "assumption that insights from biology directly translate to AGI" and no attempt for "substantial adaptation (to) oversimplify the complex and unique challenges inherent in computational systems", since there is no attempt to use computational systems for AGI development using info-autopoiesis. Info-autopoiesis is used to show that

the development of AGI is something that is considered highly improbable given that we engage in an info-autopoietic existence.

As stated previously, the paper does not argue for the use of info-autopoiesis in the development of AGI. On the contrary, it argues for the impossibility of achieving AGI given info-autopoiesis. The info-autopoietic process does not depend on "philosophical argumentation and theoretical extrapolation". Its fundamental argument relies on describing how an organism interacts with its environment with the intention of adapting the environment to its needs. This unique description allows for a tie-in to Shannon's mathematical theory of communication, which relies on syntactic information to become effective [7]. Note that Shannon communication is a development that is the basis for the digital world that we live in. So, what other "empirical testing or computational modeling to support the claims" is needed? Close examination of Shannon's theory requires determining how syntactic information materializes. What becomes evident is that humans engaged in the process of communication must have the capability for the semantic interpretation of their surrounding environment, which then results in communication using syntactic information. This cyclical process of sensing–information–action, or the self-creation of semantic and syntactic information, is at the bottom of how we become what we become. This is all detailed in the paper. It also becomes evident that there is no information in our surrounding environment, except for the interpretable syntactic information that we put there. Looking back at Shannon, it is possible to argue that the syntactic information relevant to oral communication comes about from the pressure modulation of the air by our vocal organs that allow for the information of language sounds. Language sounds are syntactic creations that are no different from all other human creations using our hands or other bodily organs to interact with our environment. So, all human creations are nothing more than the material embodiment of information (the etymological origin of the word information is applicable here) as syntactic information that needs interpretation by other humans.

Further, the "rigorous empirical studies" requirement imposed by Damaševičius becomes irrelevant to info-autopoiesis, since there is no attempt to achieve AGI. But a challenge that I ask Damaševičius to undertake is to identify an instance of syntactic information creation by humans capable of semantic information generation. If such an instance exists, info-autopoiesis loses its validity. An additional observation is that info-autopoiesis is always reliant on "empirical" syntactic creations with which we engage every instant of our life, interpreting and creating them.

To reiterate, info-autopoiesis is just that, information self-creation, which has nothing to do with developing AGI. We interpret our environment using our sense organs to change it in our own image. Regarding the "practical implications of the framework for AI development", info-autopoiesis is just the way that we deal with the world, and this is just one more activity that human beings perform in living their lives. Researchers should be self-aware that they are the result of the unavoidable process of info-autopoiesis. What they should realize is that we are incapable of achieving AGI because of our inability to syntactically create things that are capable of semantic information synthesis.

The quandary of knowing when to stop is certainly present in all our activities. Info-autopoiesis pretends to set a limit to human knowledge based on fundamental principles. So, the purview of info-autopoiesis is not only AGI. The premise is simple; all human creations are fundamentally syntactic creations that are incapable of semantic interpretation. Anything that falls under this rubric is subject to this. Another way that we can visualize this is to say that humans are endowed with Syntactic Touch: everything that we touch turns into syntactic information [8]. This is akin to the Midas Touch: everything that King Midas touched turned into gold. Is Syntactic Touch a blessing or a curse?

Further, human exploration is timeless. Nothing has ever stopped humankind from thinking the unthinkable. Neither will info-autopoiesis and its Syntactic Touch prescription. In a more practical note, I do not see anyone in the AI community rushing to make better judgements as to their AGI creations because of info-autopoiesis. What seems important

to them is when and from whom the next billion-dollar investment is forthcoming. They have no time for info-autopoietic platitudes. In any case, no one wants to admit that their perspective of the world is invalid, not even the least prestigious of researchers.

Info-autopoiesis lies outside of mainstream research, not only "mainstream AI research". Also, recall that info-autopoiesis does not deal with "advancements in machine learning, neural networks, and cognitive architectures". This precludes adoption "by the broader AI research community". However, a case can be made for discussing "how info-autopoiesis can directly influence current AI development practices would strengthen the framework's relevance".

5. Paragraph 4

This paragraph is an excellent description of the current state-of-the-art in AI research, and the potential reach of info-autopoiesis.

6. Paragraph 5

The suggestion by Damaševičius about a more extensive evaluation of info-autopoiesis and the Marxian Alienation Theory in a world increasingly dependent on AI and machine learning (AIM) is surely valid and worth pursuing. Some inroads in this direction may be found in [9]. Additionally, the impact of information on the Marxian theory of value is also relevant [10].

7. Paragraph 6

I commend Damaševičius for recognizing the "profound and multifaceted" "implications" of info-autopoiesis "in the realms of AI development and the ethical considerations of technology's role in society". Though the relevance of a bio-inspired approach is clearly an important consideration, it needs to be tempered by the limitations imposed by our Syntactic Touch. We may benefit from looking at other bio-inspired inventions such as airplanes, where the resemblance between them is more in the realm of heavier-than-air mobility. But it is clear that developments in the realm of virtual assistants such as Siri or Alexa, and robots that serve as companions for older adults that "robust AI systems that embody a deeper understanding of human-like learning and decision-making processes" are needed. And in implementing such systems, an info-autopoietic focus might be applicable.

Also, I wholeheartedly agree with the perspective by Damaševičius that "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", including "advocating for more transparency, safety, and governance in AI research and applications".

8. Paragraph 7

The suggestions by Damaševičius of enhancing info-autopoiesis by "specific modifications and extensions (that) could be beneficial" need careful consideration. Firstly, "integrating empirical research methodologies, such as computational modeling or simulations that mimic biological information processes" is unavoidably faced with the limits of syntactic information creation that info-autopoiesis poses. To reiterate, info-autopoiesis does not seek to serve as a means to AGI development or achievement. Secondly, info-autopoiesis cannot serve as an extended "framework to include a comparative analysis with existing cognitive architectures in AI". Thirdly, if "interdisciplinary collaboration, incorporating insights from neuroscience, cognitive science, and systems biology" is to be achieved, these disciplines would have to incorporate into their belief systems the fact that information is self-produced and that there is no information to be found in the environment, except for the syntactic information that humans put there. This would probably preclude any useful collaborations. I applaud Damaševičius for putting forth these suggestions.

9. Paragraph 8

It is gratifying that Damaševičius draws attention to the multidisciplinary concern of info-autopoiesis for "bridging the gaps between AI, cognitive science, ethics, and philosophy", besides pushing "for a deeper integration of biological and cognitive sciences into AI research", as well as recognizing an "integrative approach encourages a more holistic view of intelligence, potentially leading to AGI systems that better mimic human cognitive processes and decision-making".

It is also noteworthy that Damaševičius points out that Cárdenas-García [2] puts an "emphasis on understanding the inherent limitations of AI systems (which) speaks directly to ethical concerns regarding the deployment and control of AI technologies". Furthermore, "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". 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", leading to possibly influencing "policy-making, particularly in how AI technologies are regulated and integrated into critical areas such as healthcare, security, and education", and overall encouraging "a convergence of disciplines, fostering a conversation that could lead to more responsible and innovative approaches to both the development and governance of AI".

10. Paragraph 9

The last paragraph suggests that "several areas for further research emerge as critical for advancing the theory and its practical application".

The first encourages "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". As mentioned previously, info-autopoiesis is not a means for the development or achievement of AGI. It is an approach to discover how humans engage with their surroundings and explain how they become what they become in order to discover how these findings limit what is possible for human beings to accomplish in all fields of human effort.

The second rightly proposes "interdisciplinary studies combining insights from neurobiology, cognitive psychology, and information theory could enrich the understanding of how info-autopoiesis might be realized in both natural and artificial systems. Such studies could help in identifying specific biological processes that could be emulated in AI systems to enhance their autonomy and adaptability". There is no doubt that info-autopoiesis needs further study and development considering its unique fundamental aspects.

The third suggestion requires "exploring the ethical and societal implications of AI systems designed around the info-autopoietic framework would be vital". Focusing "on the consequences of deploying such AI systems in various sectors, examining issues such as transparency, predictability, and controllability". And the final suggestion is for "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". As mentioned previously, info-autopoiesis is not an approach to AI system development and implementation.

11. Discussion and Conclusions

This response seeks to discuss the comments of Damaševičius [1] related to the paper by Cárdenas-García [2]. The purpose is to, in some instances, clarify the text of the article, and, in others, offer something further to consider. The response addresses each paragraph.

Info-autopoiesis is a novel framework that seeks to explain how living organisms function on a fundamental level. The commented paper is an application of info-autopoiesis

to discover the true nature of AI and the implications for AGI. The most notable finding is that Syntactic Touch is a limiting factor for the development of AGI. In particular, no human syntactic creation can have the capability for the generation of semantic information.

I would like to thank Robertas Damaševičius for his comments and suggestions. In many instances, they are right on target and emphasize the positive aspects and potential for an info-autopoietic vision as applied to AI. On minor instances, there is an overestimation of the potential of an info-autopoietic approach to AI systems. I am glad that this was done in the spirit of searching and seeking the full potential of info-autopoiesis. It is in this disposition of friendship and understanding that I would encourage a collaborative exchange to sort out any differences and seek potential areas of collaboration.

References

1. Damaševičius, R. Comment on Cárdenas-García, J.F. Info-Autopoiesis and the Limits of Artificial General Intelligence. *Computers* **2023**, *12*, 102. *Computers* **2024**, *13*, 178. [CrossRef]
2. Cárdenas-García, J.F. Info-Autopoiesis and the Limits of Artificial General Intelligence. *Computers* **2023**, *12*, 102. [CrossRef]
3. McCulloch, W.S.; Pitts, W. A logical calculus of the ideas immanent in nervous activity. *Bull. Math. Biophys.* **1943**, *5*, 115–133. [CrossRef]
4. Dawid, A.; LeCun, Y. Introduction to Latent Variable Energy-Based Models: A Path Towards Autonomous Machine Intelligence. *arXiv* **2023**. [CrossRef]
5. LeCun, Y. A Path towards Autonomous Machine Intelligence. Available online: https://openreview.net/pdf?id=BZ5a1r-kVsf (accessed on 2 July 2024).
6. Murphy, H.; Criddle, C. Meta AI chief says large language models will not reach human intelligence. *Financial Times*, 22 May 2024.
7. Shannon, C.E. A Mathematical Theory of Communication. *Bell Syst. Tech. J.* **1948**, *27*, 379–423. [CrossRef]
8. Cárdenas-García, J.F. The Central Dogma of Information. *Information* **2022**, *13*, 365. [CrossRef]
9. Cárdenas-García, J.F. Info-Autopoiesis and Digitalisation. *New Explor. Stud. Cult. Commun.* **2022**, *2*, 110–132.
10. Cárdenas-García, J.F. Labour Productivity: The Link Between Use-Value, Value, and Information. *Cosm. Hist. J. Nat. Soc. Philos.* **2023**, *19*, 327–355.