

Article

Not peer-reviewed version

Artificial Intelligence: A Kalam and Sufi Perspective

[A. M. Khalili](#) *

Posted Date: 6 June 2023

doi: 10.20944/preprints202306.0363.v1

Keywords: AI; Artificial Intelligence; Kalam; Sufism; Philosophical Sufism; Philosophy of Science; Science and Religion



Preprints.org is a free multidiscipline platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This is an open access article distributed under the Creative Commons Attribution License which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Article

Artificial Intelligence: A Kalam and Sufi Perspective

A. M. Khalili

Newcastle University, United Kingdom; a.m.khalili@outlook.com

Abstract: The recent remarkable progress in Artificial Intelligence (AI) has renewed the discussion on the possibility of human-level AI. Despite the difficulty of the problem and the presence of many large gaps and challenges, most people working in the field think that human-level AI is achievable, but they disagree on the date. In this paper, I briefly discuss the possibility of human-level AI from the perspective of two traditions in the Islamic world, namely Kalam and Sufism, and despite their different mode of investigation, they converge to the same conclusion on this topic.

Keywords AI; artificial intelligence; kalam; sufism; philosophical sufism; philosophy of science; science and religion

Introduction

Artificial Intelligence has recently produced many remarkable achievement and it is expected to show more in the future, however it still far from approaching human-level intelligence. Most of this progress come from Deep Learning (DL) which is very promising in pattern recognition, but it is still limited in high-level functions such as reasoning, it is also limited in generalization to new tasks [1,2]. Although recent AI systems show some abstraction and reasoning abilities, however, they seem to use pattern matching, shortcuts, and memorization of some aspect of the reasoning process [50–54]. Despite the remarkable ability of Large Language Models (LLMs) [9,70–74] in learning some patterns of the reasoning process and then apply them in different context, they still lack understanding of the coherent text they produce when they are probed more deeply [68,75–78].

Another flaw in the argument that deep learning will lead to human-level intelligence is the assumption that intelligence will somehow emerge through training neural networks without providing any convincing justification for this assumption. There is also a growing interest recently in studying artificial general intelligence [3–9,79–81]. Despite few skeptical views [60–62], most experts in the field think that human level intelligence is achievable but they disagree on the date [8]. Although a large part of what we do could be automated, however, there is still something beyond these automatable tasks, this key necessary building block is understanding. Searle [10] illustrated the basic idea through the Chinese room experiment, he argued that computation will not be sufficient for thinking, understanding, and consciousness, and the causal power of the brain should be duplicated to achieve this goal.

To further illustrate the importance of understanding in the scientific discovery context, consider how the idea of quantum computing was developed, to be able to discover the idea, one should have understanding of the binary representation, understanding of how computer programs work, and understanding of how quantum mechanics works. Then to combine these ideas together to come up with the idea of quantum computing, without understanding of each of the above concepts this process cannot be achieved. Many other problems at the frontier of science have similar nature and would require understanding to be solved, current AI systems are only showing promising results on narrower problems such as finding the mathematical equation that describes specific phenomenon [59,60,82–84]. Several other examples can be given to show that there is something beyond computational processes and without it, AI systems will keep operating at a very shallow level.

Penrose [11,85] also provided many examples to illustrate why computers will not be able to show human like understanding, he argued that understanding is not governed by rules and it is not a computational procedures. He suggested that understanding can be achieved using non

computational processes and quantum physics might be a good candidate. Palmer [34] also provided many arguments why quantum physics should play a role such as energy efficiency.

Muhtaroglu [13] discussed the possibility of achieving strong AI within both dualist and non-dualist views, where strong AI will be less challenging in a non-dualist view. He also discussed the Kalam views on free will [14]. Ritchie [15] provided a comprehensive discussion on God action in the natural world with focus on human consciousness, she argued that divine action theories that locate divine actions in a nonphysical mind are insufficient, she suggested that theistic naturalism is more compelling, where natural processes do not compete with divine actions, but participate with God in a natural manner.

Despite the potential of the Kalam and Sufi thoughts and the later synthesis between the two in addressing key challenges in the philosophical foundation of modern science and in the philosophical thoughts in general, we can only see few works that started to engage with these challenges, see for example [21,22,63–65,67,69]. In this paper I provide a brief Kalam and Sufi perspective on AI and what it says about human-level intelligence and whether it is possible or not.



[86]

Kalam Perspective

One key difference between Kalam [17–20] and other philosophical traditions in the Islamic world is that the Kalam tradition takes the compatibility between the world and divine actions and attributes more seriously when studying the natural world. Due to this key difference, each one of these traditions produced different philosophical foundations of natural science. Altaie [21,22,69] has recently discussed and summarized these key foundational principles with their implications. In this work I will focus on one key principle relevant to this work, namely causality [23–25].

In this work I will focus mainly on the Ash'arite school of Kalam with major figures like al-Ash'ari, al-Baqilani, al-Isfarayini, Ibn Furak, al-Juiani, al-Ghazali, al-Razi, al-Amidi, al-Iji, al-Taftazani, and to a lesser degree on the mu'tazilite school. After establishing God existence and his attributes, God sovereignty is one of the main theme of the Ash'arite system, nothing in the world can happen outside the will of God, this emphasis allowed their system to be more consistent than the mu'tazilite system in addressing key challenges like the problem of evil. According to the Ash'arite [23–25] nothing can have genuine causal power over anything and all causal power belong only to God. According to the Ash'arite, any deterministic view that limits God sovereignty and actions in the world is necessarily flawed. The fire does not have a causal power to burn and God is the creator of the act of burning and he might decide not to create that action, but it is God habit to usually do so. The mu'tazilite on the other hand argued that God placed a causal power in the fire to burn. The main implication of Ash'arite view is that the laws of nature can not be deterministic. This view suggests that all laws of physics -not only quantum mechanics- should be probabilistic, similarly

the laws of biology should be probabilistic, and finally the laws of intelligence, this might suggest that quantum mechanics could play a role in these fields too. Using similar reasoning, they proposed even a more radical idea namely recreation, which state that the entire world is recreated at each moment by His action, nothing can sustain its existence and without continues recreation everything will be annihilated. According to the Ash'arite, nothing has causal power, nothing can sustain its existence, and nothing can understand.

Although the Ash'arite consider rational investigation one of the main ways of knowing, the Ash'arite system shows that any deterministic view that limits God actions in the physical and the mental worlds is clearly flawed, this implies that human rational investigation cannot escape God sovereignty let alone the machines. Understanding which is a key aspect of knowing is created by God, rational investigation does not have the causal power to produce understanding on its own, God may or may not create understanding after rational investigation. According to al-Ash'ari [47] God create knowledge at rational investigation usually similar to the creation of burning when there is a fire and He may not create it, which means understanding is also probabilistic, this is more clear in the case of understanding than in the case of other natural laws. According to Nur al-Din al-Sabuni [26] a Maturidi scholar, there are two types of knowledge, a necessary (daruri) knowledge created by God without human choice like the whole is bigger than its parts, and acquired (iktisabi) knowledge created by God that is acquired by the human through senses and rational investigation. However, some Ash'arite like al-Razi [47,48] argued that knowledge is not probabilistic after rational investigation, but his view is still different from some mu'tazilite who argued for the emergence of knowledge after rational investigations [47]. Clearly it is easier to accept human-level intelligence within the mu'tazilite system which suggests that God placed a causal power in humans to understand.

The suggestion that quantum mechanics should play a role is the closest approach to the Kalam perspective. However unlike other natural laws which are applicable everywhere, high-level understanding and intelligence seems to be unique to humans, even within humans, the same rational investigation by different people not always produce understanding for some (this does not mean that a correct rational investigation will not lead to true conclusion, which is a different issue, the Ash'arites agree that a correct rational investigation will lead to true conclusion). While achieving human-level intelligence is more consistence with mu'tazilite system, the above discussion shows that from an Ash'arite perspective it is very hard to accept the possibility of human-level understanding and intelligence in machines unless He decide to create them in machines which seem to be very unlikely.

Sufi Perspective

The Sufis stress the limit of rational investigation in acquiring true knowledge. They consider unveiling or 'kashf' a higher way to acquire true knowledge. According to al-Ghazali [27] unveiling represents a higher form of knowledge. According to Ibn Arabi [28,29] there is a type of knowledge that cannot be acquired by rational investigation, like knowing the sweetness of honey. However, there are several strict criteria [30,46,49] that should be met to take the unveiling seriously, this was the subject of many disagreements between the Kalam scholars and the Sufis [31,56], and between the Sufis themselves [30,46,49]. Although unveiling could happen to anyone, usually the Sufis stress on the importance of purifying the heart to become receptive to this type of knowledge. According to al-Ghazali the true nature of things and the divine knowledge can be reflected in the mirror of the heart only if the mirror is purified and polished. Without this clear mirror, knowledge will be distorted by the ego and by the biases of the knower.

Unveiling to the Sufis represent the highest form of knowledge because it is directly unveiled by God, therefore it leads to knowing thing as they are. The senses alone will give a partial and distorted knowledge as demonstrated by al-Ghazali through many examples [32], and although rational investigation can provide a higher form of knowledge than the senses, the created understanding will be shaped and limited by the limits of the investigation method and by the limits and biases of the investigator. The self can escape from these limitations only by means of external

objective reference [33]. Probably the best way to summarize this is by what attributed to Ibn Arabi describing Ibn Sina 'It is a wonder how far this blind man reached with his crutch', blindness here refer to blindness to unveiling, and the crutch refer to rational investigation.

According to Ibn Arabi [33] the world itself is a veil, and except for the people of unveiling, all other knowledge such as rational investigation is knowledge of the veils through the veil of the self. The purification of the heart is the main way to receive this kind of knowledge, a transformational process that remove the veil to allow the self to see itself and others, as put by Chittick [33] 'removing the ignorance and obscurities that separate the true subject from the true object'. Qaysari [65,66] also argued that true knowledge of the things as they are is difficult to acquire except for hearts that have been illuminated by the light of God. The perspective and the way the self sees the world is changed by each stage of the seven stages of the transformation (see [35–38] for further discussions), until the veil is completely lifted and one reaches to his true self that can have true knowledge 'and breathed into him of my spirit' [43]. This transformational process leads to the perfect human, at this stage the sight is sharpened from the timeless sight, the Sufi starts to understand God's actions and decree in the world. He no longer knows by himself but by God, it is by Him he sees and knows 'When I Love him, I am his hearing with which he hears, and his sight with which he sees' [41]. 'It is through My Eyes that you see Me and see yourself' [42].

According to Ibn Arabi, the divine is the source of everything, we love beauty because it reminds us of Him, our search for different manifestations of beauty will not be completely satisfied until we know Him the source of beauty. Similarly he is the source of knowledge, our knowledge is from His knowledge [37]. The world is in a continues manifestation of his names, the knowledge we know is from the effect of his name the knower, which manifests throughout the history by unveiling of many insights and discoveries. The above discussion shows that from a Sufi perspective it is very hard to accept that this second important source of knowledge namely unveiling to be given to machines unless He decide to create it in machines which seem to be very unlikely.

Conclusion

In this paper, the Kalam and the Sufi perspective on AI was discussed. While achieving human-level intelligence is more consistence with mu'tazilite system, the paper showed that it is hard to accept the possibility of achieving human-level intelligence in machines from the Ash'arite and the Sufi perspectives.

References

1. Marcus, G. (2018). Deep learning: A critical appraisal. arXiv preprint arXiv:1801.00631.
2. Mitchell, M. (2021). Why AI is harder than we think. arXiv preprint arXiv:2104.12871.
3. Adams, S., Arel, I., Bach, J., Coop, R., Furlan, R., Goertzel, B., ... & Shapiro, S. C. (2012). Mapping the landscape of human-level artificial general intelligence. *AI magazine*, 33(1), 25-42.
4. Lake, B. M., Ullman, T. D., Tenenbaum, J. B., & Gershman, S. J. (2017). Building machines that learn and think like people. *Behavioral and brain sciences*, 40.
5. Clune, J. (2019). AI-GAs: AI-generating algorithms, an alternate paradigm for producing general artificial intelligence. arXiv preprint arXiv:1905.10985.
6. Hutter, M. (2004). *Universal artificial intelligence: Sequential decisions based on algorithmic probability*. Springer Science & Business Media.
7. Goertzel, B. (2021). The General Theory of General Intelligence: A Pragmatic Patternist Perspective. arXiv preprint arXiv:2103.15100.
8. Müller, V. C., & Bostrom, N. (2016). Future progress in artificial intelligence: A survey of expert opinion. In *Fundamental issues of artificial intelligence* (pp. 555-572). Springer, Cham.
9. Webb, T., Holyoak, K. J., & Lu, H. (2022). Emergent Analogical Reasoning in Large Language Models. arXiv preprint arXiv:2212.09196.
10. Searle, J. R. (1980). Minds, brains, and programs. *Behavioral and brain sciences*, 3(3), 417-424.
11. Penrose, R., & Mermin, N. D. (1990). The emperor's new mind: Concerning computers, minds, and the laws of physics.
12. Hadamard, J. (1996). The mathematician's mind: The psychology of invention in the mathematical field.

13. Muhtaroglu, N. (2018) "An Analysis of the Strong AI in terms of Two Ontologies," Templeton Science and Religion Conference: Consciousness and Artificial Intelligence, Trinity Hall, University of Cambridge and Cambridge Muslim College, Cambridge, England, 2018. https://www.youtube.com/watch?v=21y_Nnf3uSE
14. Muhtaroglu, N. (2010). An Occasionalist Defence of Free Will. In *Classic Issues in Islamic Philosophy and Theology Today* (pp. 45-62). Springer, Dordrecht.
15. Ritchie, S. L. (2019). *Divine action and the human mind* (Vol. 14). Cambridge University Press.
16. Chalmers, D. (2017). The hard problem of consciousness. *The blackwell companion to consciousness*, 2, 32-42.
17. Wolfson, H. A. (1976). *The philosophy of the Kalam* (Vol. 4). Harvard University Press.
18. Walzer, R. (1967). *Early Islamic Philosophy. The Cambridge History of Later Greek and Early Medieval Philosophy*, Cambridge, 643-669.
19. Harvey, R. (2021). *Transcendent God, Rational World: A Maturidi Theology*. Edinburgh University Press.
20. Erlwein, H. C. (2019). *Arguments for God's Existence in Classical Islamic Thought*. De Gruyter.
21. Altaie, M. B. (2017). *Daqiq al-Kalam: A Basis for an Islamic Philosophy of Science*. Cambridge Muslim College Papers, 4.
22. Altaie, M. B. (2016). *God, nature and the cause: Essays on Islam and science*. Kalam Research et Media.
23. Al-Ghazali, M. *Tahafut al-Falasifa*, p. 166-171
24. Marmura, M. E. (1998). *The Incoherence of the Philosophers (Tahafut al-Falasifa)*
25. Altaie, M. B. (2010). *Daqiq al-Kalam*, Chapter 4
26. Al-Taftazani. *Sharh al-'aqa'id al-nasafiyah. Maktabat al-kuliat al-azhariah*, Cairo, p. 15-22.
27. Lumbard, J. (2019). Abū Ḥāmid al-Ghazālī and the Art of Knowing. In *Light upon Light: Essays in Islamic Thought and History in Honor of Gerhard Bowering* (pp. 401-419). Brill.
28. Ibn Arabi, *Al-Futuhāt al-Makkeah (Part 3 – Maratib al-Ulowm)*.
29. Arif, S. (2002). Sufi Epistemology: Ibn'Arabi on Knowledge, *Afkar-Jurnal Akidah & Pemikiran Islam*, 3(1), 81-94.
30. Al-Muhāsibī, *Al-Ri'ayah Li'Huquq-il-lah*, p. 92-94
31. Rustom, M. (2014). Ibn 'Arabī's Letter to Fakhr al-Dīn al-Rāzī: A Study and Translation. *Journal of Islamic Studies*, 25(2), 113-137.
32. Al-Ghazali, M. *Almunqidh min al-Dalal*
33. Chittick, W. C. (2015). *The self-disclosure of God: principles of Ibn al-'Arabi's cosmology*. SUNY Press.
34. Palmer, T. (2020). Human creativity and consciousness: Unintended consequences of the brain's extraordinary energy efficiency?. *Entropy*, 22(3), 281.
35. Ogunnaike, O. (2015). *Sufism and Ifa: Ways of knowing in two West African intellectual traditions*.
36. Ogunnaike, O. (2020). *Deep knowledge: ways of knowing in Sufism and Ifa, two West African intellectual traditions* (Vol. 5). Penn State Press.
37. Ogunnaike, O. (2017). *Shining of the Lights and the Veil of the Sights in the Secrets Bright: An Akbari Approach to the Problem of Pure Consciousness*, *Journal of the Muhyiddin Ibn 'Arabi Society*, 61.
38. Casewit, Y. (2020). *Shushtari's Treatise On the Limits of Theology and Sufism: Discursive Knowledge ('ilm), Direct Recognition (ma'rifa), and Mystical Realization (tahqiq) in al-Risala al-Qusariyya*. *Religions*, 11(5), 226.
39. Ansari, A. *Manazil al-Sa'irin* (Chapter 93)
40. Zargar, C. A. (2022). *Transcending Character as a Quest for Union: The Place of al-Jam' in Sufi Ethical Commentaries on Khwaja Abdallah Ansari's Waystations*. *Mysticism and Ethics in Islam*.
41. Bukhari, 6502
42. Ibn Arabi, M. *Tarjuman Al-Ashwaq*.
43. Quran 15:29
44. Villani, C. (2015). *Birth of a Theorem: a mathematical adventure*. Farrar, Straus and Giroux.
45. Chollet, F. (2019). *On the measure of intelligence*. arXiv preprint arXiv:1911.01547.
46. Sohrevardi, O. *Awaref al-ma'aref* (Chapter 57).
47. al-Iji, A. A. D. *al-Mawaqif fi Ilm al-Kalam*. 'Alam al-kutub, Beirut (p. 27-28)
48. al-Razi, F. A. D. *Muhasal afkar al-mutaqadmen wa al-muta'kheren min al-olama' wa al-hukama' wa al-mutakalimen*. Maktabat al-kuliat al-azhariah, Cairo (p. 47-48)
49. Sirhindi, A. *Maktubat* (Chapter 286)
50. Saxton, D., Grefenstette, E., Hill, F., & Kohli, P. (2019). *Analysing mathematical reasoning abilities of neural models*. arXiv preprint arXiv:1904.01557.

51. Geirhos, R., Jacobsen, J. H., Michaelis, C., Zemel, R., Brendel, W., Bethge, M., & Wichmann, F. A. (2020). Shortcut learning in deep neural networks. *Nature Machine Intelligence*, 2(11), 665-673.
52. Razeghi, Y., Logan IV, R. L., Gardner, M., & Singh, S. (2022). Impact of pretraining term frequencies on few-shot reasoning. *arXiv preprint arXiv:2202.07206*.
53. Zhang, H., Li, L. H., Meng, T., Chang, K. W., & Broeck, G. V. D. (2022). On the Paradox of Learning to Reason from Data. *arXiv preprint arXiv:2205.11502*.
54. Srivastava, A., Rastogi, A., Rao, A., Shoeb, A. A. M., Abid, A., Fisch, A., ... & Kim, H. (2022). Beyond the Imitation Game: Quantifying and extrapolating the capabilities of language models. *arXiv preprint arXiv:2206.04615*.
55. Chittick, W. C. (2010). *The Sufi path of knowledge: Ibn al-Arabi's metaphysics of imagination*. Suny Press. (p. 162)
56. Al-Taftazani. *Sharh al-'aqa'id al-nasafiyah*. Maktabat al-kuliat al-azhariah, Cairo, p. 22.
57. Foudeh, S. (2017) *Maturidi Kalam and Modern Challenges to Theology, Understanding Maturidi Kalam: Legacy, Present & Future Challenges Conference* <https://www.youtube.com/watch?v=8WAgKnV25VM&t=4800s>
58. Udrescu, S. M., & Tegmark, M. (2020). AI Feynman: A physics-inspired method for symbolic regression. *Science Advances*, 6(16), eaay2631.
59. Udrescu, S. M., & Tegmark, M. (2021). Symbolic pregression: Discovering physical laws from distorted video. *Physical Review E*, 103(4), 043307.
60. Fjelland, R. (2020). Why general artificial intelligence will not be realized. *Humanities and Social Sciences Communications*, 7(1), 1-9.
61. Larson, E. J. (2021). *The Myth of Artificial Intelligence*. In *The Myth of Artificial Intelligence*. Harvard University Press.
62. Landgrebe, J., & Smith, B. (2022). Why Machines Will Never Rule the World: Artificial Intelligence without Fear.
63. Brown, J. H. (2013). The problem of reductionism in philosophy of mind and its implications for theism and the principle of soul: Framing the issue for further Islamic inquiry. *Tabah Foundation*.
64. Lahham, K. (2021). *The Anatomy of Knowledge & the Ontological Necessity of First Principles*. Tabah Research.
65. Spiker, H. (2021) *Things as They are: Nafs al-Amr and the Metaphysical Foundations of Objective Truth*. Tabah Research.
66. Qaysari, Matla' khusus al-kalim, 64.
67. Malik, S. A., & Muhtaroglu, N. (2022). How Much Should or Can Science Impact Theological Formulations? An Ash'ari Perspective on Theology of Nature. *European Journal of Analytic Philosophy*, 18(2), S8-35.
68. Mahowald, K., Ivanova, A. A., Blank, I. A., Kanwisher, N., Tenenbaum, J. B., & Fedorenko, E. (2023). Dissociating language and thought in large language models: a cognitive perspective. *arXiv preprint arXiv:2301.06627*.
69. Altaie, M. B. (2023). *Islam and natural philosophy, principles of daqiq al-kalam*
70. Lewkowycz, A., Andreassen, A., Dohan, D., Dyer, E., Michalewski, H., Ramasesh, V., Slone, A., Anil, C., Schlag, I., Gutman-Solo, T. and Wu, Y., Neyshabur, B., Gur-Ari, G., Misra, V. (2022). Solving quantitative reasoning problems with language models. *arXiv preprint arXiv:2206.14858*.
71. Bubeck, S., Chandrasekaran, V., Eldan, R., Gehrke, J., Horvitz, E., Kamar, E., Lee, P., Lee, Y.T., Li, Y., Lundberg, S. and Nori, H., Palangi, H., Ribeiro, M., Zhang, Y. (2023). Sparks of artificial general intelligence: Early experiments with gpt-4. *arXiv preprint arXiv:2303.12712*.
72. Kadavath, S., Conerly, T., Askell, A., Henighan, T., Drain, D., Perez, E., ... & Kaplan, J. (2022). Language models (mostly) know what they know. *arXiv preprint arXiv:2207.05221*.
73. Burns, C., Ye, H., Klein, D., & Steinhardt, J. (2022). Discovering latent knowledge in language models without supervision. *arXiv preprint arXiv:2212.03827*.
74. Sun, W., Yan, L., Ma, X., Ren, P., Yin, D., & Ren, Z. (2023). Is ChatGPT Good at Search? Investigating Large Language Models as Re-Ranking Agent. *arXiv preprint arXiv:2304.09542*.
75. Valmeekam, K., Sreedharan, S., Marquez, M., Olmo, A., & Kambhampati, S. (2023). On the Planning Abilities of Large Language Models (A Critical Investigation with a Proposed Benchmark). *arXiv preprint arXiv:2302.06706*.
76. Liu, J., Xia, C. S., Wang, Y., & Zhang, L. (2023). Is Your Code Generated by ChatGPT Really Correct? Rigorous Evaluation of Large Language Models for Code Generation. *arXiv preprint arXiv:2305.01210*.

77. Schaeffer, R., Miranda, B., & Koyejo, S. (2023). Are Emergent Abilities of Large Language Models a Mirage?. arXiv preprint arXiv:2304.15004.
78. Liu, N. F., Zhang, T., & Liang, P. (2023). Evaluating Verifiability in Generative Search Engines. arXiv preprint arXiv:2304.09848.
79. Adams, S., Arel, I., Bach, J., Coop, R., Furlan, R., Goertzel, B., ... & Shapiro, S. C. (2012). Mapping the landscape of human-level artificial general intelligence. *AI magazine*, 33(1), 25-42.
80. Goertzel, B. (2014). Artificial general intelligence: concept, state of the art, and future prospects. *Journal of Artificial General Intelligence*, 5(1), 1-48.
81. Lake, B. M., Ullman, T. D., Tenenbaum, J. B., & Gershman, S. J. (2017). Building machines that learn and think like people. *Behavioral and brain sciences*, 40.
82. Zheng, D., Luo, V., Wu, J., & Tenenbaum, J. B. (2018). Unsupervised learning of latent physical properties using perception-prediction networks. arXiv preprint arXiv:1807.09244.
83. Iten, R., Metger, T., Wilming, H., Del Rio, L., & Renner, R. (2018). Discovering physical concepts with neural networks. arXiv preprint arXiv:1807.10300.
84. Schawinski, K., Turp, M. D., & Zhang, C. (2018). Exploring galaxy evolution with generative models. arXiv preprint arXiv:1812.01114.
85. Penrose, R. (2004). *The road to reality: A complete guide to the physical universe*. Jonathan Cape.
86. <https://twitter.com/Beautif69668200>

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.