The behavior-based origin of life and the problem of genetic representation

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Abstract. Traditionally, there has been a dispute about whether metabolism or replication came first during the origin of life. While the metabolism-first approach focuses on chemical self-constitution of an individual, the replicator-first approach focuses on generational self-replication of a population of informational molecules. Yet both implicitly agree that the first forms of life were isolated, passive, and static individuals. Both ignore the intermediate timescales of activity between chemical self-constitution and population evolution: no mention is made of behavior and development [3]. These assumptions are challenged by a new generation of metabolism-first approaches, which emphasize that movement and adaptive behavior could have played an important role right from the start [4, 5, 1]. I consider how this behavior-based approach to the origin of life can inform our thinking about a number of traditional problems. For example, it was long believed that the pre-biotic evolution of a hypercycle of chemical processes is unstable because it can be invaded by parasitic compounds, which do not contribute to the subsistence of the rest of the network. But later on it was realized that this is only the case in a well-mixed (non-spatial) environment, and that spatial embedding can make hypercycles immune to parasites. We can push this shift in perspective even further by showing that it is possible to make use of the instabilities introduced by parasites as a source of motility, which can even confer adaptive advantages [2, 7]. Indeed, there may even have been minimal cognition at the origin of life [6]. Thus, to some extent in this field we see a recapitulation of the history of cognitive science. If so, might this comparison provide us with a non-representational theory of the origin of the genetic system, which is traditionally treated as the first representational system?

REFERENCES

[1] Matthew D Egbert, Xabier E Barandiaran, and Ezequiel A Di Paolo, 'Behavioral metabolution: The adaptive and evolutionary potential of metabolism-based chemotaxis', *Artificial Life*, **18**(1), 1–25, (2012).

[2] Tom Froese, Takashi Ikegami, and Nathaniel Virgo, 'The behavior-based hypercycle: From parasitic reaction to symbiotic behavior', in *Artificial Life*, volume 13, pp. 457–464, (2012).

[3] Tom Froese, Nathaniel Virgo, and Takashi Ikegami, 'Life as a process of open-ended becoming: Analysis of a minimal model', in *Advances in Artificial Life, ECAL 2011: Proceedings of the Eleventh European Conference on the Synthesis and Simulation of Living Systems*, pp. 250–257. Cambridge, MA: MIT Press, (2011).

[4] Tom Froese, Nathaniel Virgo, and Takashi Ikegami, 'Motility at the origin of life: Its characterization and a model', *Artificial life*, **20**(1), 55–76, (2014).

[5] Martin M Hanczyc, 'Metabolism and motility in prebiotic structures', *Philosophical Transactions of the Royal Society B: Biological Sciences*, **366**(1580), 2885–2893, (2011).

[6] Martin M Hanczyc and Takashi Ikegami, 'Chemical basis for minimal cognition', *Artificial Life*, **16**(3), 233–243, (2010).

[7] Nathaniel Virgo, Tom Froese, and Takashi Ikegami, 'The positive role of parasites in the origins of life', in *Artificial Life (ALIFE), 2013 IEEE Symposium on*, pp. 1–4. IEEE, (2013).

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