Review of: "Self-Replication, Spontaneous Mutations, and Exponential Genetic Drift in Neural Cellular Automata"

Shokhan M. Al-Barzinji[1]

1 University of Anbar, Iraq

Potential competing interests: No potential competing interests to declare.

This paper is a **notable contribution** to ALife and NCA research, demonstrating innovative uses of neural networks to explore evolutionary dynamics. While it has clear limitations, it serves as a valuable proof of concept and a foundation for further work toward true Open-Ended Evolution. The abstract effectively introduces the key contributions:

1. Demonstrates **self-replication** with **inheritable mutations** and **exponential genetic drift** using NCA.
2. Claims novelty by leveraging the flexibility and generality of neural networks, without direct training for evolutionary behaviors.

The abstract sets clear expectations for the reader, although it could briefly highlight limitations or future prospects for balance. The introduction does an excellent job of situating the work within the broader ALife and cellular automata (CA) contexts:

1. Discusses the longstanding challenge of achieving **Open-Ended Evolution (OEE)** in artificial systems.
2. Provides historical background, from von Neumann's self-replicating CA to Conway's "Life" and more modern NCA developments (Mordvintsev et al., 2020).
3. Highlights the limitations of traditional CA (e.g., reliance on hand-designed rules) and the potential of NCAs to autonomously discover complex behaviors.

However, some aspects could benefit from elaboration:

1. The discussion on "laws of physics vs. biology" (e.g., Adams et al., 2017) is intriguing but tangential; a clearer linkage to the paper's goals would help.
2. A stronger emphasis on how NCA specifically enables "closed-world" modeling would improve clarity.

Suggestions for improvement:

1. A more concrete roadmap for addressing current limitations (e.g., specific architectural innovations or training techniques) would be beneficial.
2. Integration of evolutionary complexity metrics could provide a more robust framework for evaluating OEE.