Simulating Representational Communication in Vervet Monkeys using Agent-Based Simulation

Ankit Gupta[*1,2], Francis Steen[3]

[*]Corresponding Author: guptaa23@msu.edu
[1]Department of Computer Science and Engineering & [2]Program in Ecology, Evolution, and Behavior, Michigan State University, East Lansing, MI, United States;
[3]Department of Communication, UCLA, Los Angeles, CA, United States

1. Background and Motivation

Human languages are composed in part by discrete patterns of sound that can be linked to meanings through social learning. What are the evolutionary pressures that drove the development of referential vocalization? In this project, we explore the survival costs and benefits of referential alarm calls in a savanna-dwelling primate. We base our model on the discovery that the African vervet monkey (Chlorocebus pygerythrus) gives acoustically different alarm calls to different predators (Struhsaker, 1967; Seyfarth & Cheney, 1980a, b, c), conditional on context (Deshpande et al., 2023). In the following, we simulate the costs that vervets incur by monitoring their environment for predators, issuing alarm calls, running to escape potential predators, and foregoing foraging in favor of seeking refuge, and track the survival outcomes. Our goal is to determine the envelope of evolvability of representational signaling in the parameter space of a troop of primates in an African savannah environment.

2. Simulation Logic and Methodology

Initiating with a population of vervets and their respective predators, the simulation is guided by the dual parameters of hunger and fear level amongst the vervets. Their quest to diminish hunger through foraging is complicated by the appearance of predators, which elicits a fear response. This encounter prompts vervets to either persist in their foraging efforts or retreat to safe zones (such as stony ground, trees, or bushes), alongside broadcasting an alarm call with a limited radius of efficacy. Predators, meanwhile, meander through the ecosystem, seeking out vervets to maintain their energy through predation. Data was collected across three alarm potency levels: 0 (no call), 1 (general alarm,

directing vervets to the nearest refuge - not necessarily safe), and 2 (specific alarm, guiding vervets to the appropriate refuge), alongside variations in vervet resource levels to assess the alarm call's enduring impact.

3. Current Results & Conclusion

Analyzing simulation data from 30 replicates across 50 generations, an interesting pattern emerged. Despite frequent extinctions, vervets with zero alarm potency were observed to survive through significantly more generations compared to those with higher potency levels (Figure 1), as evidenced by the results of the Kruskal-Wallis test, ($H(2) = 77.83$, $p < .001$). Investigating the root causes behind early extinctions by examining average energy levels and predation rates across alarm potency levels for each resource condition also revealed a significant effect of alarm calls. Specifically, vervets without alarm calls had higher energy levels ($H(2) = 196.26$, $p < .001$) and lower predation rates ($H(2) = 10.49$, $p < .01$) compared to those with more potent alarm calls.

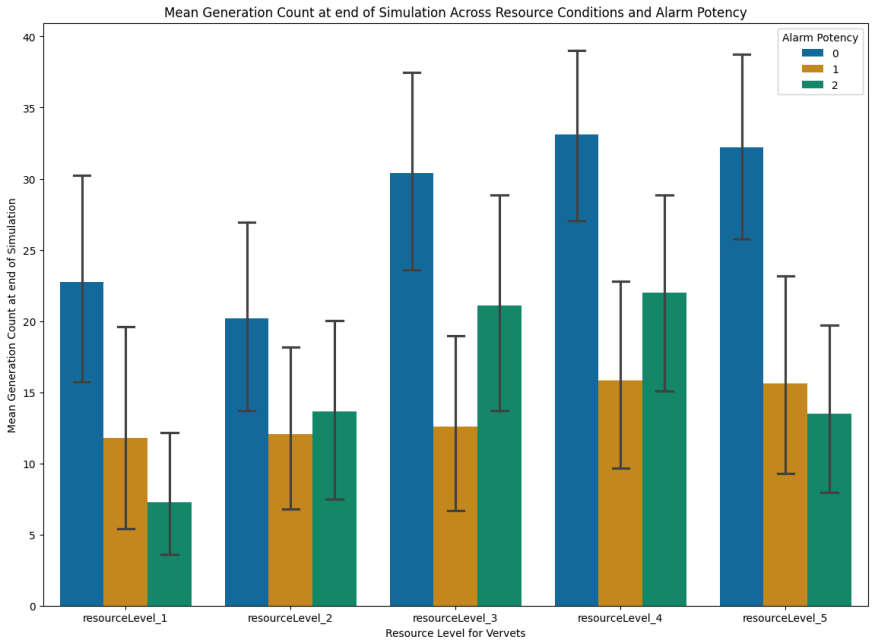

Figure 1: Plot comparing average generation count vervets survive across alarm potency levels across resource conditions. Error bars represent 95% confidence interval.

The aforementioned resource experiment findings on alarm calls prompt further study into variables like predation success probability, energy decay rates, and scanning frequency to reach more conclusive results about alarm call efficacy.

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