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Evolutionary Advantages of Loneliness with an Agent-Based Model

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Abstract : The feeling of loneliness is not uncommon in modern society, and yet, there is a fundamental lack of understanding in its origins and purpose in nature. One interpretation of loneliness is that it is a subjective experience that punishes a lack of social behavior, and thus its emergence in human evolution is seemingly tied to the survival of early human tribes. Still, a common counterintuitive response to loneliness is a state of hypervigilance, resulting in social withdrawal, which may appear maladaptive to modern society. So far, no computational model of loneliness' effect during evolution yet exists; however, agent-based models (ABM) can be used to investigate social behavior, and applying evolution to agents' behaviors can demonstrate selective advantages for particular behaviors. We propose an ABM where each agent contains four social behaviors, and one goal-seeking behavior, letting evolution select the best behavioral patterns for resource allocation. In our paper, we use an algorithm similar to the boid model to guide the behavior of agents, but expand the set of rules that govern their behavior. While we use cohesion, separation, and alignment for simple social movement, our expanded model adds goal-oriented behavior, which is inspired by particle swarm optimization, such that agents move relative to their personal best position. Since agents are given the ability to form connections by interacting with each other, our final behavior guides agent movement toward its social connections. Finally, we introduce a mechanism to represent a state of loneliness, which engages when an agent's perceived social involvement does not meet its expected social involvement. This enables us to investigate a minimal model of loneliness, and using evolution we attempt to elucidate its value in human survival. Agents are placed in an environment in which they must acquire resources, as their fitness is based on the total resource collected. With these rules in place, we are able to run evolution under various conditions, including resource-rich environments, and when disease is present. Our simulations indicate that there is strong selection pressure for social behavior under circumstances where there is a clear discrepancy between initial resource locations, and against social behavior when disease is present, mirroring hypervigilance. This not only provides an explanation for the emergence of loneliness, but also reflects the diversity of response to loneliness in the real world. In addition, there is evidence of a richness of social behavior when loneliness was present. By introducing just two resource locations, we observed a divergence in social motivation after agents became lonely, where one agent learned to move to the other, who was in a better resource position. The results and ongoing work from this project show that it is possible to glean insight into the evolutionary advantages of even simple mechanisms of loneliness. The model we developed has produced unexpected results and has led to more questions, such as the impact loneliness would have at a larger scale, or the effect of creating a set of rules governing interaction beyond adjacency.

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