Getting your Drift – Activity designs for grappling with evolution

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Abstract: This poster presents the design of activities for engaging with the evolutionary mechanism known as *genetic drift*. Operating in the informal learning setting of a natural history museum, our design builds upon the theoretical notion of *embodied modeling* in an agent-based tradition, extending this foundation to address the special challenges associated with genetic drift and to take advantage of the affordances of immersive multi-touch technologies and of the museum setting.

Introduction

This poster presents the design of an activity for learners to engage with the phenomenon of *genetic drift* Genetic drift is a key mechanism of evolution involving traits that convey no survival advantage to organisms. The passage of such a trait to future generations is determined purely by chance and the distribution of variations in the population. However, against the intuitions of many, the feedback loop of this purely-probabilistic selection process over time creates a population that is completely homogenous with respect to the trait. Our design challenge is to develop activities that foreground genetic drift and enable visitors to engage with this mechanism. This work is a part of a larger project to make key evolutionary mechanisms accessible in informal settings and has been pursued in the context of a museum of natural history in a large Midwestern city with visitor groups often consisting of families, siblings, or close friends.

Major Issues Addressed

As the noted geneticist Theodosius Dobzhansky (1973) famously wrote, "nothing in biology makes sense except in the light of evolution." At the same time, nothing is more controversial in the American education landscape. According to recent surveys (Gallup, 2012), 46% of Americans do not believe in evolution, and a shockingly small number, only 15%, say they believe in naturalistic evolution. Thus, one key barrier to increasing understanding of evolutionary mechanisms in the general public involves simply engaging with the conversation in an open spirit of inquiry. Beyond the barrier of acceptance or belief, educators and psychologists have described a host of student misconceptions about evolution (e.g., Andrews et al, 2012; Catley et al, 2004; Sinatra et al, 2003; Wilensky & Novak, 2010). For the specific context of genetic drift, two of the most important of these misconceptions involve difficulties with conceiving of randomness as playing a positive role in producing emergent structure (Wilensky & Resnick, 1999) and challenges about conceptualizing the passage of "deep time" (Gee, 2000).

Theoretical and Methodological Approaches

To address the challenge of supporting learners in reasoning about genetic drift, our activity design extends principles of *embodied modeling* (Wilensky & Reisman, 2006) within an agent-based approach (Epstein & Axtell, 1996) to biological systems. In agent-based modeling (ABM), elements of a system are represented by simulated computational entities whose interactions result in emergent whole-system behaviors. ABM offers many affordances for learning about complex systems, as it enables learners to tap into intuitions that they have about agent-agent interactions. In the context of genetic drift, however, it is not sufficient for learners to project themselves into the system as *agents*. In fact, the very premise of drift (i.e., that it involves traits that convey no advantage) suggests that the agent-perspective will be indifferent about those traits. Our extension to embodied modeling with ABM involves introducing *new perspectives* within a simulated biological system that permit learners to leverage practices of gaming to engage and reason about the phenomenon of drift in that system.

Designing interactive experiences for museums offers a host of additional challenges including software usability issues and creating a socially engaging experience for diverse visitor groups that unfolds in a very brief timespan. In our activity, visitor dyads are recruited to engage in "games about evolution" on a large multi-touch tabletop interface on the exhibit floor. Our initial game-scenario presents an ecosystem containing a population of lily-pad bugs that vary in the trait of body color (see Figure 1a), a trait which has no impact on the bugs' chances of survival. Visitors are told that these bugs feed off of the algae that grows on the lily-pads, and that when they have eaten enough they reproduce asexually by dividing. Visitors can move the lily pads around in the pond at any time, simply by dragging them (Figures 1b and 1c) with their fingers. Their goal is to keep as many *varieties* of bugs alive as possible, for the duration of the game (600 'ticks,' or about two minutes). Besides the pond-view itself, feedback on the bug population is given in numeric and graphical form.

After the pair has explored this first game, they are invited to play a second game. Here, the two members of group are asked to position themselves on opposite sides of the tabletop display. This time, their objective is to end the 600-tick game with a population that exhibits *exactly two* of the five body-color variations. After the games, participants are asked to individually reflect on the experience and articulate their reasoning and observations about what ideas they tried out and what happened to the bug populations.

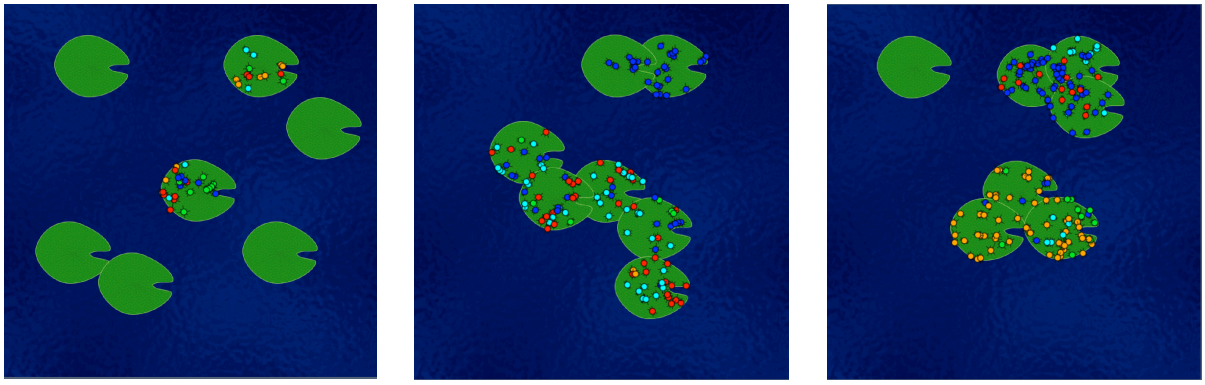

Figure 1a. Initial State of the game. Figures 1b and 1c. Configuring the pond.

Discussion and Significance

In these activities, visitors engage with the bug population by controlling structural features of the environment. These interactions make salient the effects of key factors such as carrying capacity and geographical barriers on the growth patterns of the population, and in particular on the emergence of drift effects. In the first game, drift is figured as the antagonist or opponent, as participants work against it to preserve diversity. In the second game, visitors work in a contrary direction, using drift as a tool to select two particular trait variations for survival. In both games, visitors have a tactile means of constructing environments with the goal of resisting drift or harnessing it as a mechanism to create desired population-level outcomes. These interactions offer the means to grapple with the notion of random factors operating on traits in populations; to engage with a range of genetic drift effects within the brief timeframe that museum visitors typically spend with an exhibit; and to leave with a vivid experience that remains open for reflection and interpretation by the friends-and-family group.

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