

The population memetics of DarwinTunes

In order to use DarwinTunes to study the evolution of culture we have modelled our experiment on laboratory evolutionary studies of microbes and small animals such as worms and flies (e.g., Elena and Lenski 2003). Many of the population genetic forces that influence the outcome of such studies apply to ours as well; but since we are studying the evolution of cultural artifacts – songs – we use the term “population memetics”.



The initial population

All the songs in a DarwinTunes population are descended from a single pair of randomly generated songs – an Adam and Eve as it were – except that our songs don’t have genders. These songs were then allowed to mutate, recombine and reproduce to form a population of 100 descendants. Our experiment begins with this population.

Fitness and selection

Visitors to DarwinTunes listen to these songs and rate them. DarwinTunes waits until 20 songs have received ratings. The 20 songs are sorted according to their rating, and the 10 best songs are allowed to reproduce; the worst 10 songs are killed. The 10 reproducing songs pair at random and each mating produces two daughters. When 20 daughters have been produced, the 10 parents die and the 20 new songs are added to population so that the population size remains at 100. The intensity of selection – and hence the rate of evolution – depends on the rate at which ratings are made.

Reproduction and recombination

When two songs mate they produce two daughter songs. Each daughter inherits a mixture of her parents' features by a process analogous to genetic recombination. The "chromosomes" in DarwinTunes are actually tree structures of code. There is only one tree structure per song, that is, they are "haploid". During recombination a small number of tree nodes are chosen at random in one parent (each node has a 1 in 1000 chance of being chosen). The same number of nodes are then chosen at random in the other parent. The chosen nodes – "crossover nodes" – are then

paired up and the two parents are copied from the roots upwards. When a crossover node is reached, the copying switches over to the other parent. After this recombination event the daughters together contain the same amount of genetic material as their parents did.

Mutation

De novo variability is generated by "mutation". Each node of a daughter's tree structure has a 1 in 1500 chance of being mutated. 80% of the mutations are "point mutations" which alter the value of a single atomic piece of information (e.g. note length, note position, wavelength multiple). The remainder are "macro mutations" which swap, copy, insert, delete or replace part of the tree structure. Insertions and replacements involve the generation of random subtree structures.

Experimental design

We are particularly interested in the effects of selection on our populations. However, a reproducing, mutating population of finite size will also evolve by chance – “drift.” The design of our experiment has two features to help us factor out the effect of drift. The first is replication. Each DarwinTunes user will be automatically assigned to one of several replicate populations – though they won't know which one. The second is a set of control populations. These are populations of songs that reproduce, recombine and mutate just like our experimental populations but which are not under selection. The idea is that any trait or process that we see in all the selected populations, but not in the unselected controls, must be due to the effects of selection rather than drift. To put it another way, this design should permit us to identify “adaptations.”

Expectations

What, exactly, will we be looking for in our evolving populations? Frankly, we're not sure – nor do we have to be. One of the beautiful things about this evolutionary experiment is that we will have a perfect record of its entire history. We will know the code for every song in the entire history of every population. This is the equivalent of having the complete genome sequence of every creature in an evolutionary experiment – something that is never available. Knowing that code we will be able to resurrect any song that ever existed in a population and study its features. For example, if a particularly successful mutation occurred in a particular song we can listen to it and trace that feature throughout the rest of the population's history. We will have a complete genealogy: we will know when a song was born, when it died, who its parents were and, if it reproduced, who its daughters were. And we will have the complete selective history of the population. All this means that we will be able to study the evolutionary dynamics of song in extraordinary detail.

References

S.F. Elena and R. Lenski. 2003. Evolution experiments with microorganisms: The dynamics and genetic bases of adaptation. *Nature Review Genetics* 13: 457-467