Frequency Dependent Selection

Alan R. Rogers

September 24, 2013

What is a sociopath?

- bad actor
- no conscience
- doesn't bond with others
- promiscuous
- marries but then abandons family
- often arrested
- charming
- moves around a lot

- Sociopathy is heritable
- Why should selection favor such an allele?

Frequency-dependent Selection

- Selection does not always produce adaptation
- Under certain circumstances, it does produce adaptation
- The crucial difference: whether fitness depends on frequency
- Evolution of social behavior is usually frequency-dependent
- The evolution of culture

Evolution of handedness


- Fill mouth with paint, hold one hand to wall, blow paint through a tube held in other hand.
- Which hand would you use?

Evolution of handedness


- Most right-handers hold tube with right hand; make print of left, and vice versa.
- Left: made between 10,000 and 30,000 y ago in a French cave. Right: made recently by a French university student.

Handedness over 10,000 years

	negative hands	
	left	right
Paleolithic	264 (77.0%)	79 (23.0%)
Modern	138 (77.1%)	41 (22.9%)

(Faurie & Raymond 2004)

Handedness of French population has not changed in 10,000 y.

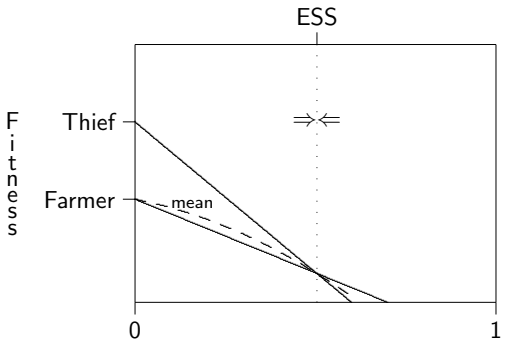
How does handedness evolve?

- Handedness is heritable.
- Left-handedness is common among tennis players, boxers, etc.
- More common in societies where homicide rate is high. Ranges from 3% to 27%.
- Faurie & Raymond hypothesis: rare type has advantage in fights.

A model: Farmers and Thieves

1. The population contains two types:
   Farmers live off what they produce.
   Thieves live off what they steal from farmers.
2. Each person has a single parent.
3. Each person is identical to that parent.

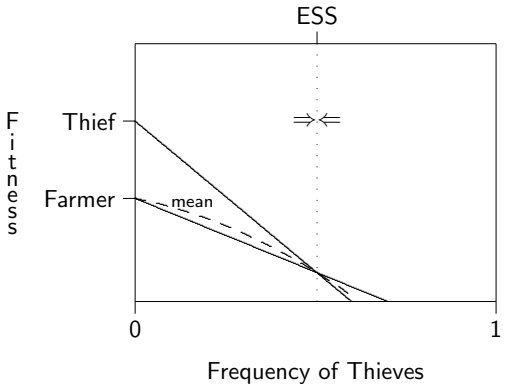
Farmers and Thieves



At LEFT:

- thieves rare
- stealing is easy
- high fitness
- freq of thieves increases

Farmers and Thieves



- At RIGHT:
  - thieves common
  - stealing is hard
  - freq of thieves decreases
- Lines cross at equil.
- Mean fitness decr.

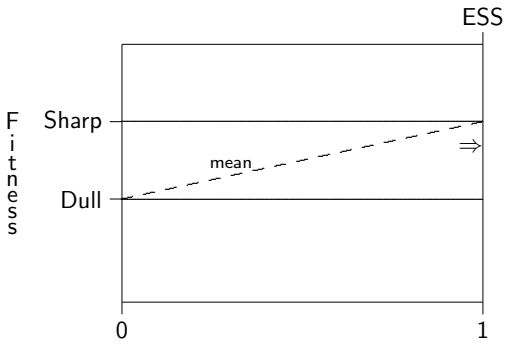
Outline

- Selection does not always produce adaptation
- Under certain circumstances, it does produce adaptation
- The crucial difference: whether fitness depends on frequency
- Evolution of social behavior is usually frequency-dependent
- The evolution of culture

Another model: Squirrels

1. The population contains two types:
   - **Dull** Some squirrels have dull claws and often fall out of the tree
   - **Sharp** Others have sharp claws and seldom fall
2. Each squirrel has a single parent.
3. Each squirrel is identical to that parent.

Evolution of Sharp Claws



- sharp claws: high fitness
- frequency doesn't matter
- equilibrium at right
- mean fitness increases

The crucial difference

- Selection always increases the mean fitness of the population when the fitness of each genotype is independent of all genotype frequencies. This case is called frequency-independent selection.
- When fitnesses *do* depend on frequencies, selection *may or may not* increase the mean fitness of the population. This case is called frequency-dependent selection.

When selection lowers mean fitness, the whole population is worse off. This form of natural selection does not make the population better adapted to its surroundings.

Evolution of social behavior is usually frequency-dependent. Consequently, we should *not* expect all patterns of social behavior to be adaptive.

Outline

- Selection does not always produce adaptation
- Under certain circumstances, it does produce adaptation
- The crucial difference: whether fitness depends on frequency
- Evolution of social behavior is usually frequency-dependent
- The evolution of culture

How does genetic evolution affect culture?

- You inherit behaviors by learning.
- Ability to learn is a genetic adaptation.
- Does this mean that learned behaviors will tend to be adaptive?

This problem is hard to study in humans. Let us strip it down to its essentials, as we did with farmers and thieves.

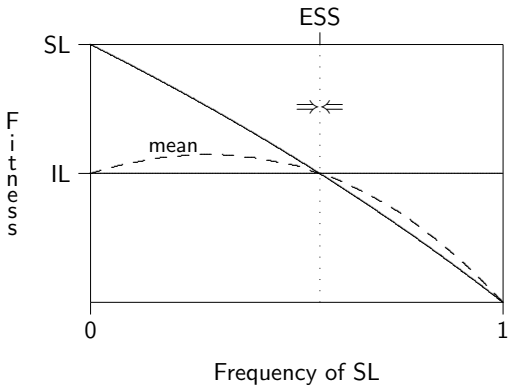
What foods should a Snerdwump eat?

- Snerdwumps are a hypothetical species that inhabits a varying environment.
- What should a Snerdwump eat?
- Answer depends on state of environment.
- Some Snerdwumps cope by individual learning: they learn what to eat by costly trials and errors.
- Others cope by social learning: they copy the diet of an older individual.

Model of cultural evolution among Snerdwumps

1. The population contains two types: (1) individual learners and (2) social learners.
2. Each individual has a single parent.
3. Each individual is identical to that parent.

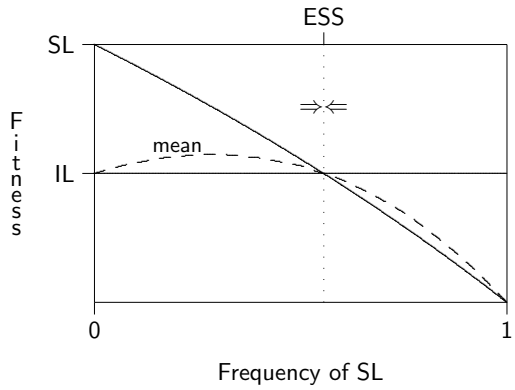
Evolution of Culture



At LEFT:

- SL rare; always copy IL
- get up-to-date info w/o cost
- high fitness

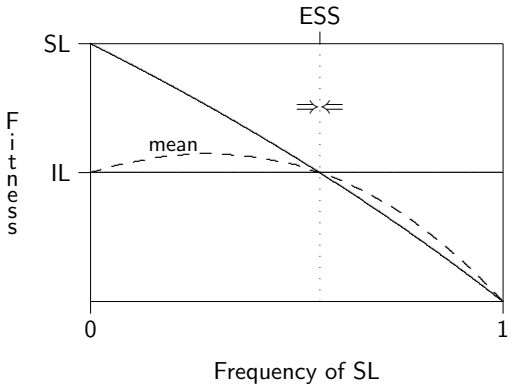
Evolution of Culture



At RIGHT:

- SL common: copy SL
- get out-of-date info
- low fitness

Evolution of Culture



- equilibrium where lines cross
- mean fitness unchanged

Summary

Frequency-independent selection
: *produces adaptation.*

Frequency-dependent selection
: *may or may not.*

Social traits
: *usually have frequency-dependent fitnesses. Maladaptive behavior such as sociopathy can evolve.*

culture
: *is social. Is it adaptive? Why?*