Genetics vs. Environment in Behavioral Development

Two ways to get difference in behavioral phenotype (e.g., song)

A

Different genes

\[ G_1 \]

\[ G_2 \]

Same environment

\[ E_A \]

Development

Different traits

B

Same genes

\[ G_1 \]

\[ G_1 \]

Different environments

\[ E_A \]

\[ E_B \]

Development

Different traits

(Fig. 2.1 from Alcock 6th Ed.)
Why Genetics Matters in Study of Behavior

Evolutionary issues

• The view that behavior evolves by natural selection assumes a genetic basis for behavioral traits
• Testing hypotheses about trait evolution may require tests of this assumption

Mechanistic issues

• Genes have role in development and operation of neural machinery underlying behavior, hence gene function must be explored as part of causal basis of behavior
• The tools of genetics provide ways of dissecting genetic mechanisms
Review of Natural Selection

Natural selection has three components

• Variation
  - Variation in phenotype among members of same population
  - A population is a group of interbreeding individuals of the same species

• Inheritance
  - “Like begets like”
  - Or, phenotypic differences are produced by genotypic differences

• Differential survival and/or reproduction
  - Some phenotypic variants have higher chance of surviving and reproducing
  - Or, there are differences in FITNESS correlated with phenotype

Natural Selection = Differential Success of Inherited Variants
Five Ways to Study Role of Genes in Producing Behavioral Differences Among Animals

• Isolation Experiment
• Compare relatives
• Hybridization studies
• Artificial selection
• Single-gene (molecular genetic) approaches

Can be used to quantify “heritability”: useful for relating to evolutionary questions
Isolation Experiments

• Basic logic
  • Goal is to test whether trait depends upon particular environmental cues or experiences
  • Rear in isolation from these experiences

• Example 1: Garter snakes and banana slugs

Garter snakes from coastal habitats in CA (but not from inland habitats) like banana slugs

So do UC Santa Cruz students (their school mascot is the banana slug)
Isolation Experiments-cont’d

• More on garter snakes

- Coastal snakes reared in lab like slugs, but inland snakes don’t
- This is not dependent on experience with slugs (or with adult snakes)
Isolation Experiments-cont’d

• Example 2: Preferred migratory direction in blackcap warblers

Hand-reared birds orient in preferred migratory direction during “migratory restlessness” (Fig 3.1 from Alcock)

Southbound blackcaps follow two main routes out of central Europe (Fig. 3.2 from Alcock)
Compare relatives

- Basic logic
  - To test whether “like begets like,” compare offspring and parents (or other classes of relatives; e.g., siblings)
  - Ideally, rear in “common garden”--hold environmental conditions constant
  - “Heritability” is measure of strength of genetic effects

- Classic example: Francis Galton’s study of human traits

Francis Galton (Darwin’s cousin!)
Compare relatives--cont’d

Height in humans: first attempt to measure heritability (and first use of concept of “regression” ***)

Regression line is best fit to data (intermediate heritability)

*** The term “regression comes from Galton’s observation that inherited traits exhibit “regression toward the mean”--offspring of extremely tall or short parents are not as different from the mean as their parents are. This is evidence of non-genetic effects on inheritance
Jan 13: Genetics--comparing relatives

Compare relatives--cont’d

Heritability of body color of male guppies

And genetic correlation of female color preference with male color
Hybridization

Basic logic
- Breed individuals expressing different phenotypes
- Examine phenotypes of offspring are dependent on phenotypes of parents

Single-locus case (e.g., Mendel's peas):
- Two distinct phenotypes continue to be seen in hybrids and later descendant generations
- Behavioral example: “hygenic” behavior in honey bees
Hybridization--cont’d

Multilocus case (far more common for behavioral traits)
- Trait results from action of many genes of small effect
- Hybrids are typically intermediate in phenotype between the parents

Example: innate migratory orientation of blackcap warblers
- Birds from western and eastern Europe have different preferred migratory directions
Hybridization--cont’d

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Example: innate migratory orientation of blackcap warblers
• Birds from western and eastern Europe have different preferred migratory directions
• Their offspring prefer an intermediate direction
Artificial selection

Logic

- If trait evolved by natural selection, then it should be possible to change it by artificial selection

- A response to artificial selection is evidence of heritable variation for the trait being selected (and the stronger the response to selection, the higher the heritability)

The **only** difference between artificial selection and natural selection is that a human breeder, rather than the natural environment, determines which variants have higher success
Artificial selection--cont’d

Example of artificial selection

Learning speed in honey bees

Bees learn to extend proboscis on presentation of specific odors

Learning speed can be artificially selected, hence is heritable

From Brian Smith, OSU
Single Gene/Molecular Genetic Approaches

Logic
- Cause mutations in single genes (generate mutant variants)
- Screen for behavioral traits affected by mutations
- Map gene’s location on the chromosome and determine its product
- The main use of this approach is not to determine whether a trait is under genetic control, but what the genes are

- Flies are shocked in presence of particular odor
- Can learn to avoid it

**Mutant flies are bad at remembering (or at learning in the first place)**
Hybridization--cont’d

Multilocus case: Example 2: cricket song

Hybrids of two different cricket species sing intermediate song (Bentley & Hoy)

- Thus pattern of inheritance in hybrids may indicate whether many or few genes underlie traits
- Also it may provide evidence of genetic correlations among traits