

Psychology 105 Chapter 2

Biopsychology - Part 3 Genes and Behavior

Spring 2008

Biopsychology - Outline

- Part 1: Internal communications in the body
- Part 2: The Brain, Mental Processes and Behavior

Part 3: Genetics and Behavior: Nature and Nurture

- Genes and Environment defined
- Studying nature and nurture: twin and adoptee studies
- Nature and nurture studies of
 - Temperament
 - Intelligence

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Studying Nature and Nurture

➤ **Behavioral Genetics** - the study of the relative contributions of **genetic and environmental influences** on behaviors and traits

▪ Genes

- biochemical units of heredity that make up the chromosomes and contain individual's genetic code
- segments of DNA, each of which is capable of controlling synthesis of at least one protein

▪ Genome

- the complete set of instructions for making and regulating an organism (human, other animal, plant)
- consists of all the genetic material in an organism's chromosomes
- About 20,000-25,000 genes in human genome (reduced from earlier estimates, textbook not up to date here, but portions of genes can be activated at different times)

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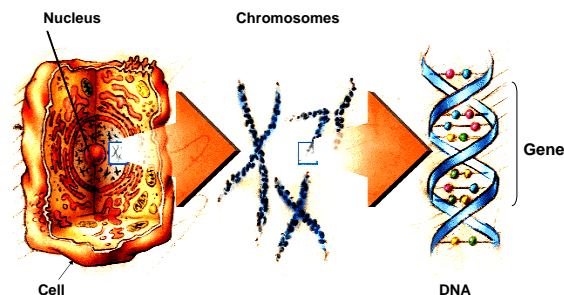
Terminology

- **Genotype**: an organism's genetic code
- **Gene expression**: process that uses information contained in genes' DNA to turn that information into proteins
 - Can be modified by many environmental factors
- **Phenotype**: Observable physical and behavioral characteristics of an organism
 - Represents outcome of influences of genotype and environment

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Genes: Location and Composition



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Environment

- **Environment** - every non-genetic* influence and experience, including:
 - Prenatal nutrition, chemistry, maternal disease, maternal stress
 - Parents, siblings, peers, other people
 - Education, training, exposure to knowledge and experience
 - Culture
 - Nutrition, disease, chemical exposure
 - Stressors, events in life

*It's tricky to separate genetic from environmental effects; chemicals produced by one gene may contribute to the internal environment - which in turn can influence the expression of other genes

Not all genes are active at any given time; some are active, others are turned off.

- **Epigenetic Change**: general term for environmental control of gene expression - when genes are turned on or turned off

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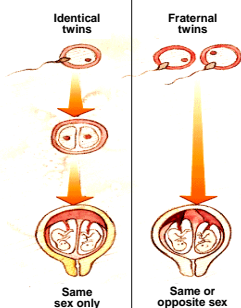
Twin Studies

➤ How do you measure the relative contributions of genes and environment to variations in a trait, such as temperament or intelligence?

➤ Identical twins: Identical genes

- Prenatal environment: nearly same
- A: Raise in birth family: similar environment
- B: Separated at birth and adopted: different environments
- → Variability between identical twins in adopted families is measure of environmental + genetic influence;
- → Variability between identical twins raised together is measure of genetic influence (mostly).
- Epigenetic changes contribute to differences between identical twins:
 - infant twins show few differences in number of genes that have been turned on or shut down
 - elderly twins show a large number of differences

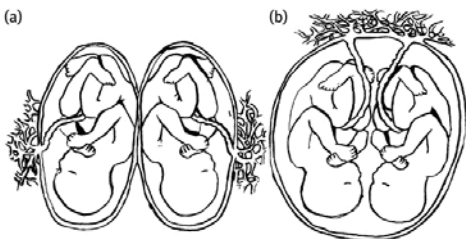
Twins: Prenatal Environment



- Identical Twins (MZ)
 - develop from a single fertilized egg that splits in two, creating two genetically identical organisms (MZ - **monozygotic**)
- Fraternal Twins (DZ)
 - develop from separate eggs
 - genetically no closer than brothers and sisters, but they share the fetal environment (DZ - **dizygotic**)

Twins: Prenatal Environment

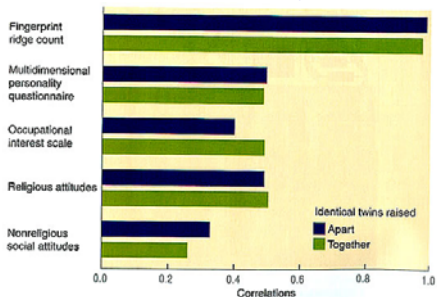
➤ Two placental arrangements in identical (MZ) twins



Studies of Twins Raised Apart

- MZ Twins raised apart are about as similar as twins raised together in *personality and temperament, activity levels, interests, intelligence and attitudes, even some EEG patterns and psychological disorders*; DZ twins vary a lot more, together or apart
 - → Home environment has little impact on these variables*; they appear to be determined by genetics to a great degree
- Love: The spouses of MZ twins are no more alike than the spouses of DZ twins and hardly more alike than random pairs of people!
- *Criticisms of twin studies:
 - Identical twins have same or highly similar prenatal environments
 - Adoptive parents are often selected to be similar in background, social status and intelligence to biological parents: variation in environments between separated, adopted twins is often small
 - Identical twins, because they look and initially behave alike, may evoke similar responses from people in their environment
 - Researchers of twins may be biased more towards seeing traits in common vs. traits that differ

Minnesota Twin Study Correlations



Correlation coefficients between identical twins raised together (green) vs apart (navy) on several different measures. Similar correlations suggest there is a genetic component for the measure. (Bouchard, et. al., in Freberg, 2006, p 128)

Temperament: Nature or Nurture?

- How much of the variability in temperament is due to genes and how much to environment (parenting, experiences, etc.)? Research has found that:
 - Newborn babies vary markedly in **emotional excitability and reactivity**
 - Reactive newborns → reactive at 9 months; Calm newborns → calm at 9 months. High correlations remain through childhood.
 - Impulsive toddlers tend to become impulsive adults; inhibited toddlers are more likely to remain inhibited as adults
 - Some shy, retiring children become more outgoing as teenagers, but outgoing children rarely become shy teens
 - MZ twins have more similar temperaments than DZ twins
 - Adopted children's temperaments are more similar to their biological parents' than adoptive parents' temperaments

Environment and Brain Development

➤ Many studies have demonstrated that the environment an animal is raised in affects brain development:

Independent Variable: environment

Dependent Variables: Brain changes (weight, #synapses)

Rosenzweig and Krech (1972) in Myers, 2004, p 119.

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Breeding for Intelligence: Maze-bright and Maze-dull rats

Tyron (1934) trained large group of rats to run in a maze (original population)

- Mated males and females who made fewest errors (maze-bright), and males and females who made most errors (maze-dull)
- Mated best maze-bright offspring together, and worst maze-dull offspring
- By eighth generation, almost no overlap in performance of maze-bright and maze-dull offspring.
- Cross-fostered offspring, so maze-dull offspring were raised by maze-bright parents, and v.v.; there was no effect on performance
- Later studies suggested that maze-brights were less emotionally reactive (calmer) than maze-dulls

Tyron, 1934, cited in Pinel, 2006, p 43

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Maze-bright and maze-dull rats raised in enriched and impoverished environments

Maze-bright and Maze-dull rats raised in impoverished vs. enriched environments show an effect of environment:

- Impoverished environment: plain wire cage
- Enriched environment: tunnels, ramps, visuals, variation

At maturity, maze-brights performed about the same in a maze, regardless of environment

Maze-dulls raised in an enriched environment performed almost as well as maze-brights; maze dulls did worse in an impoverished environment

➔ Environment had greatest effect on genetically less capable rats

Genetic strain of rats, based on performance in mazes

Cooper and Zubeck (1958), cited in Pinel, 2006, p. 43

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Can we breed for temperament?

➤ Foxes raised for fur are difficult to handle; researchers in USSR began breeding more docile foxes together, and within 30 generations had very tame foxes

<http://cbsu.tc.cornell.edu/ccgr/behaviour/Index.htm>

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Genetic and Environmental Differences

Infants from one village moved to two locations, randomly

Small town with famine, poor nutrition

Small town with lots of food, great nutrition

Differences between groups of kids due to genetic plus environmental factors

All kids grow poorly, but some grow better than others: av ht = 5'4"

All kids grow well, but some grow better than others: av ht = 5'9"

Differences within each group of kids due to genetic factors

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➤ You cannot conclude that observed differences between two groups are due to genetics, if the two groups were not raised in the same environment.

➤ Differences between the two groups are due both to hereditary + environmental factors.

You cannot conclude that heredity is a component of observed differences between groups of individuals, **UNLESS you can demonstrate that the environments in which they were raised were the same or very similar.**

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Supplementary Slides

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Environmental control of gene expression - 1

- Not all genes are active at once
- Environmental factors can "turn on" or "turn off" genes
 1. Hormones regulate gene expression:
 - Sensory input → Neural networks trigger hormonal secretions → genes turned on, regulated, or turned off by hormone



Pigmentation of butterfly *araschnia* controlled by a hormone, which is controlled by temperature during pupa stage

Gilbert, S. (2005). <http://www.las.ac.in/bioci/feb2005/55.pdf>

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Environmental control of gene expression - 2

2. As an embryonic inducer
 - Intestines in embryo do not form properly in a germ-free environment; gut bacteria are necessary for proper formation of intestines
3. Molecules bind to sites on DNA, with long-term, even cross-generational, effects
 - Presence/absence of nutrients (e.g., folate) modifies development of embryo by modifying what binds to DNA
 - Folate donates methyl groups, which bind to certain sites on the DNA molecule, preventing neural tube defects in developing embryo

Epigenetic Change: general term for environmental control of gene expression

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Gender Identity: Transgender

- Differences between sexes arise from genes on sex chromosomes, different concentrations of sex hormones (pre- and post-natal), different treatment of "boys" and "girls" by their society
- X and Y chromosomes are not absolute determinants of **gender identity** (the gender each person experiences him/herself to be). Neither is environment.
- **Transgendered individuals:** Individuals who experience lack of fit between societal expectations for sex (male/female) and gender (masculine/feminine)
 - Genetic males (XY) who feel like and respond to the environment as if they were females
 - Genetic females (XX) who feel like and respond to the environment as if they were males
 - Possible causes:
 - Exposure to mismatched sex hormone as embryo or fetus
 - Removal of external genitals as infant (injury or amorphous genital development [hermaphrodite]), surgically creating a female-like appearance in a child with XY chromosomes; such children were/are usually raised as girls
 - Other???

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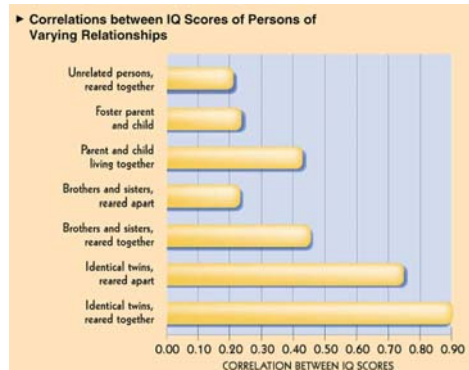
Intelligence, Genetics and Environment

- **Intelligence - definitions**
 - the ability to acquire knowledge, reason, and solve problems effectively
 - a general term encompassing various mental abilities, including the ability to remember and use what one has learned, in order to solve problems, adapt to new situations, and understand and manipulate one's environment
 - "Intelligence is the ability to face problems in an unprogrammed (creative) manner." (S.J. Gould)
- Intelligence is a **hypothetical construct**, that is, a concept or characteristic that is not directly measurable but is inferred from behavior
- Intelligence is **NOT IQ**, not a score on an intelligence test, though the test tries to measure intelligence relative to other people

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IQ - Heredity vs. Environment



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Heredity vs. Environment: IQ Score Differences among Racial Groups

- Observations:
 - Average IQ scores for Caucasian Americans are about 15 points higher than for African Americans
 - Average IQ scores for Americans from middle-income homes are about 15 points higher than for Americans from low-income homes
- Does socioeconomic status (poverty vs. affluence) influence IQ scores? And correlate with "race"? What factors often accompany poverty?
 - Malnutrition, social isolation, sensory deprivation
- Is "race" even a valid criterion for classifying human beings?
 - Many biologists and geneticists say no.
 - Individual differences within "races" are much greater than group differences between "races."

IQ Score Differences among Racial Groups

- Jensen (1969) and Herrnstein (1994): Claimed IQ differences are due to hereditary factors that differ between "races"
- Criticisms of Jensen and Herrnstein - environmental factors may impact measures of intelligence:
 - Effects of long history of racism in US
 - Different teacher expectations based on color
 - Differences of opportunity in education
 - Different average economic status
 - Differences in culture: less family support for staying in school?
 - Bias built into various IQ tests may favor one group over another

Bias: "Typical" IQ Test questions

- How much would one's culture and educational background influence the ability to answer these questions?
 - ➔ Select the answer-pair that expresses a relationship most similar to that expressed in the capitalized pair.
 - ➔ Which one of these five is least like the other four?
- | | |
|---|---|
| <p>CLUB : GOLF as</p> <ol style="list-style-type: none"> 1. type : book 2. ball : soccer 3. glove : baseball 4. racket : tennis 5. board : chess | <ol style="list-style-type: none"> 1. Bison 2. Kangaroo 3. Cow 4. Deer 5. Donkey |
|---|---|

Bias: The Chitling IQ test

- 1. A "handkerchief head" is:
 - (a) a cool cat,
 - (b) a porter,
 - (c) an Uncle Tom,
 - (d) a hoddi,
 - (e) a preacher.
 - 2. Which word is most out of place here?
 - (a) splib,
 - (b) blood,
 - (c) gray,
 - (d) spook,
 - (e) black.
 - 3. A "gas head" is a person who has:
 - (a) fast-moving car,
 - (b) stable of "lace,"
 - (c) "process,"
 - (d) habit of stealing cars,
 - (e) long jail record for arson.
- (This test was designed to illustrate the cultural bias in IQ tests; it's based on items that would be common knowledge among inner city African Americans - in the 1970s. See Ch. 2 Supplementary Info for link to complete test) (answers: c,c,c)

IQ and Heredity vs. Environment

- You can demonstrate that heredity is a component of the intelligence of an individual, though you cannot demonstrate what percentage
- Books by Jensen (1969) and Herrnstein (1994) tried to make the case that racial differences in IQ scores are based on inherited abilities. HOWEVER...

You cannot demonstrate that heredity is a component of observed differences between groups of individuals, **UNLESS you can demonstrate that the environments in which they were raised were the same or very similar.**

Scarr and Weinberg Adoption Study

- Compared African-American and white children who had been adopted as infants into similar home environments: white, above-average IQ, middle-income.
- Result: NO differences found between African-American and White children in IQ scores measured during adolescence (average around 110)
- Implications: NO evidence for racial/ethnic genetic differences in or intelligence

Are Tall People More Intelligent?

- Old data: On average, tall people have greater earning power and are more likely to advance to high positions in business and government. Why? Social dominance? Self-esteem? Discrimination against short people?
- Recent study: hypothesizes that tall people are more intelligent, and hence advance to higher positions
 - Tall people, on average, have higher scores on intelligence tests than shorter people.
 - The differences appear in scores on cognitive tests taken as early as 3 years old and persist through childhood
 - Moderately strong positive correlations found between height and some scores of intelligence (verbal, numerical)
- Does being tall make you smarter? Does being smart make you taller? Genetics or environment? (watch out here...)
 - Prenatal nutrition, early childhood nutrition affect both cognitive ability and stature
 - Tall people may self-select into occupations that require more cognitive, intellectual skills and less physical skill

Case, A. and Paxson, C. (August, 2006). "Stature and status: Height, ability, and labor market outcomes." NBER Working Paper No. 12466.