

Cognitive and Behavioral Genetics: An Overview

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What is “Cognitive and Behavioral Genetics”?

- Behavioral genetics = Genetic basis of behavior:
 - How genes wire up a brain capable of seeing, moving, learning, thinking, talking, etc.
 - How genes make people alike and different
- Cognitive genetics: internal generators of behavior (learning mechanisms, emotions); not just behavior itself

Why Cognitive & Behavioral Genetics?

- Scientific problem:
 - Complex brain
 - Complex genome (~ 30,000 - 50,000 genes, ~ half expressed primarily in brain)
 - How does one produce the other?
- Nature-nurture debate
 - How does biological endowment interact with experience, culture, to produce mind & behavior?

Why cog. & beh. genetics, cont.

- Social issues with genetic aspect:
 - Inequality?
 - Crime?
 - Education and parenting?
 - Mental illness?
 - Homosexuality?
- Why now?
 - Evidence from behavior genetics research on importance of genes to behavior
 - Advances in genetic technology

A New, Interdisciplinary Field

- Psychology & cognitive science: Which aspects of the mind are genetically structured? How can we best characterize them?
- Genetics: Where are these genes? What are they? How are they inherited?
- Neuroscience: How do genes build a brain with certain psychological abilities?

How do Genes Influence Behavior?

- Gene = stretches of DNA coding for a protein.
- DNA makes RNA makes protein.
- Proteins make brains:
 - Rate of growth of neurons in different parts.
 - Chemical gradients along which cells migrate and axons grow.
 - Molecular locks and keys that encourage neurons to connect properly.
 - Programmed death of cells and synapses.
 - Generation of firing patterns.
 - Wiring rules, e.g.,: "Neurons that fire together wire together; Neurons out of synch fail to link"

Genes versus Learning: Too Crude a Distinction

- Brains take in information from the environment and change as a result.
- Short term = perception.
- Long term = learning and memory.

Therefore:

- Genes are not an alternative to learning.
- Genes make learning possible.
 - Language acquisition module
 - If-then rules: "If people usually kiss up to you, be demanding; Else, be meek.")
- Real issues: How many systems does the brain contain, and how do they learn?

Different Kinds of Questions within Behavioral Genetics:

1. What psychologically significant genes do all members of *Homo sapiens* have in common?
 - Compare human and chimpanzee genome
 - Compare genomes of normal and atypical people

2. How do men and women differ biologically?

- Effects of genes on Y-chromosome (prenatal, postnatal hormones)
- Effects of having 1 vs. 2 X-chromosomes
- Effects of genomic imprinting

3. Do ordinary people differ from one another for genetic reasons?

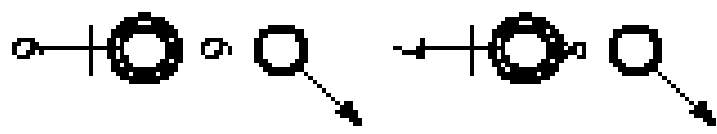
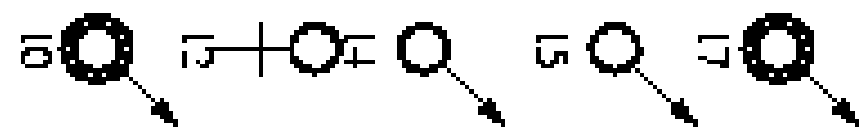
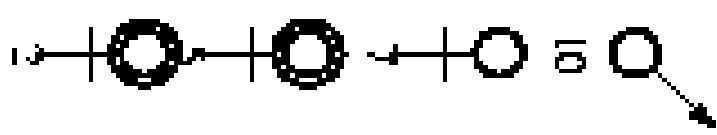
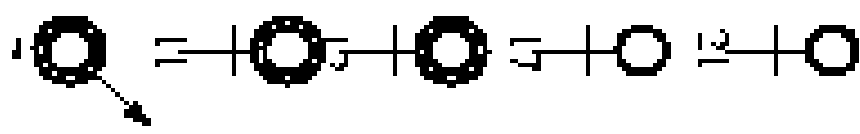
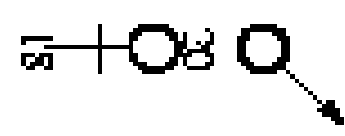
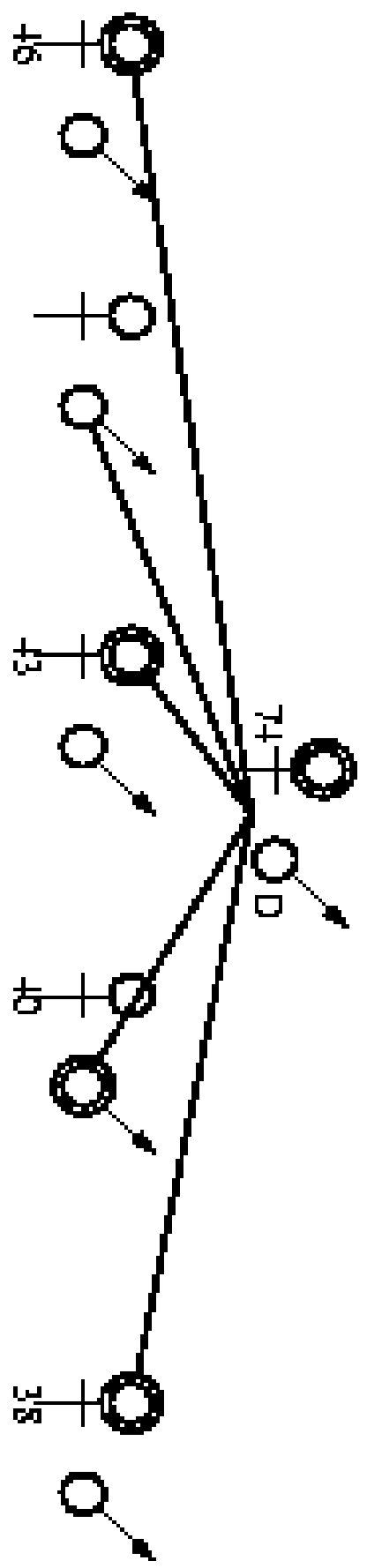
- Adoption studies
- Twin studies
- Other methods (e.g., inbreeding depression)
- Quantitative Trait Locus studies (QTL)

4. Are genes the cause of specific rare, atypical, or disease conditions?

- Familial aggregation
- Twin studies
- Pedigree analysis
- Linkage studies
- Gene-hunting
- Functional analyses

A Case Study: Familial Speech & Language Impairment

- Familial aggregation (“runs in families”): elevated probability of language impairment in relatives of proband
- Twin studies: LI highly concordant in MZ twins, more so than in DZ twins
- Pedigree analysis:



- Assessment: Classification unambiguous, nature of condition less so:
 - Gopnik & Crago: Grammatical feature blindness
 - Vargha-Khadem et al.: More general (speech, orofacial apraxia, IQ)
- Pedigree: suggests a single, dominant, autosomal, fully penetrant gene

Duff

THE DUFF & HOWARD ZWARTZ

WHAT'S FOR DINNER?
... NOT ME, I HOPE.

THAT'S THE ONE THAT
RECEIVED THE HUMAN
GENE IMPLANT.



ROBOTMAN by Jim Meddick



ROBOTMAN by Jim Meddick



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- Genes: Fisher, et al. (1998) Localisation of a gene implicated in a severe speech and language disorder. *Nature Genetics*.
 - *SPCH1*, long arm of Chromosome 7
 - Several genes w/ products active in brain:
 - growth factor
 - adhesion molecule
 - signaling molecule
 - kinase
 - active in frontal lobes, basal ganglia, other regions

Normal Variation: “The Three Laws of Behavioral Genetics”

- *First Law:* All human behavioral traits are heritable.
- *Second Law:* The effect of being raised in the same family is smaller than the effect of the genes.
- *Third Law:* A substantial portion of the variation in complex human behavioral traits is not accounted for by the effects of genes or families

Heritability: Differences Among Individuals that Correlate with Genetic Variation

- Variance: measure of variability in a group.
- Heritability =

$$\frac{\text{Variation Due to Genetic Differences}}{\text{Total Variation in the Group}}$$

Heritability, cont.

- “Heritable” \neq “Innate”
 - Strange consequences:
 1. Innate traits can have zero heritability (e.g., number of legs).
 2. Heritable traits can be environmentally determined (e.g., consequences of good looks).
- Direct vs. Indirect genetic determination.:
- Direct = protein
 - Indirect = everything else.

Heritability, cont.:

3. Heritability depends on the environment
(determines how much variation there is):
 - Uniformly well watered field: differences among plants are due to genes.
 - Half of field is watered, half dry: genetic differences are small (proportionally)
4. Heritability assumes *additive* effects of genes.
5. Heritability within a group says nothing about differences between groups.

Measuring Heritability in Humans



- Monozygotic Twins (100%) versus Dizygotic Twins (50%).
- Monozygotic Twins raised apart.
- Biological (50%) versus Adopted Siblings (0%).

Measuring Effects of Heredity & Environment

- Variance: (approx) average squared difference from mean.
- Variance can be *divided*: How much of the variation is correlated with one potential cause versus another
- Question: how much of the variation in personality is correlated with genes, family environment, other causes?

1. The twin method:

- Monozygotic (identical) twins share 100% of their genes.
- Dizygotic (fraternal) twins share 50% of their genes (just like other full siblings).
- Assumption: Identical twins share their environment to the same extent as fraternal twins.

Twin method, cont.

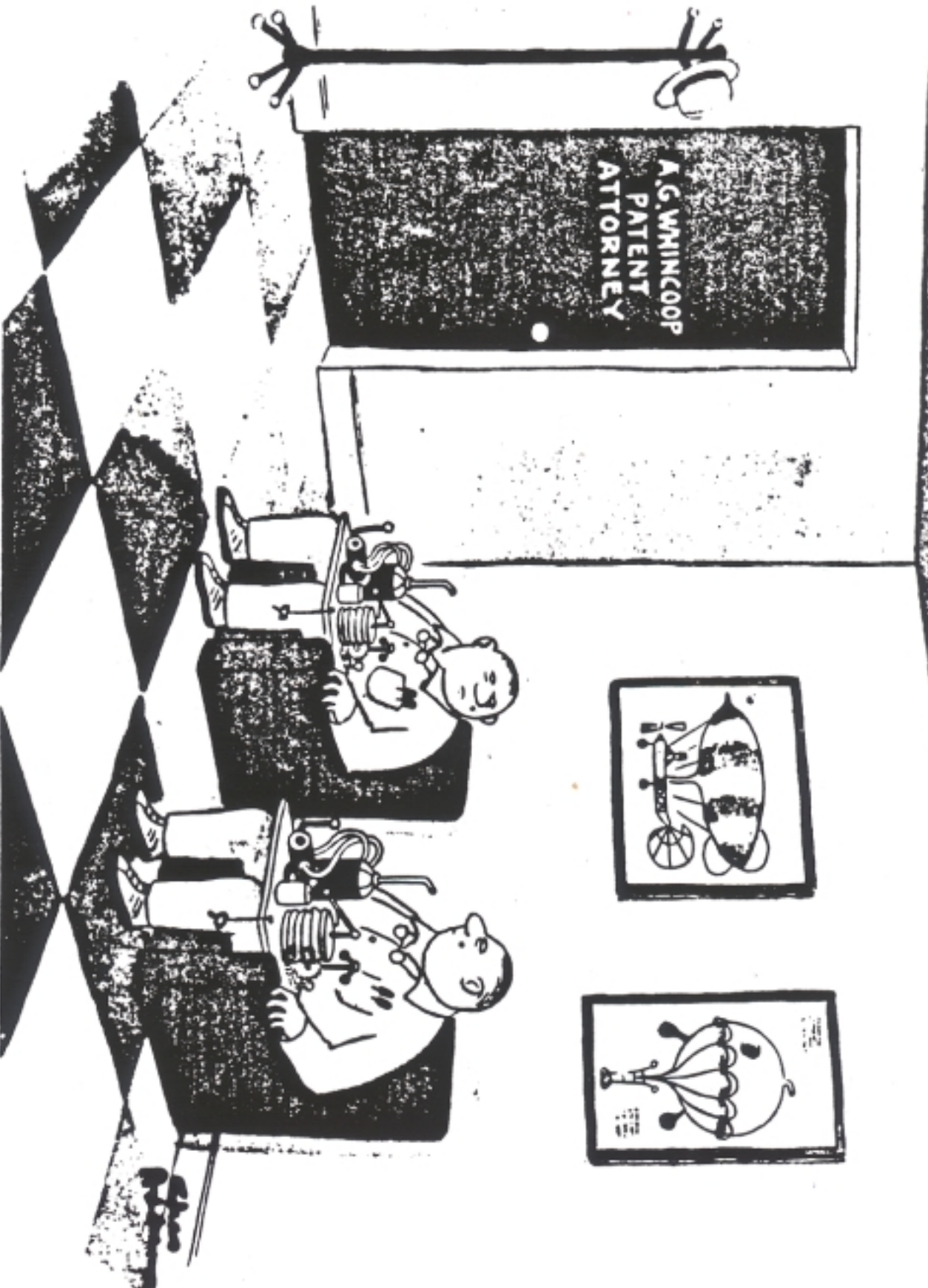
- **Heritability (h^2)** = % of variance due to genetic differences = $2(r_{MZ} - r_{DZ})$
 - High when MZ twins more similar than DZ twins
- **Shared (common) environment (c^2)** = % of variance due to environment shared by a pair of twins but different from one twin pair to another (effects of family, neighborhood) = $(r_{MZ} - h^2)$
 - High when both DZ twins and MZ twins are highly similar
- **Nonshared environment (e^2)** = % of variance due to environment *not* shared by a pair of twins: prenatal differences, accidents, diseases, differential treatment = $(1 - r_{MZ})$
 - High when MZ twins are not very similar

2. The adoption method.

- Heritability: compare similarity of biological versus adoptive siblings
- Shared environment: look at similarity of adoptive siblings (compared to random pairs of people)
- Nonshared environment: = what's left over

What's Heritable in Humans?

- First law: Almost all individual differences, in part (.30 – .80):
 - IQ
 - Personality
 - Life outcomes (divorce, crime, alcoholism, smoking...)



Separated at birth, the Mallifert twins meet accidentally.

Objective Tests: MMPI (Minnesota Multiphasic Personality Inventory)

- I am troubled by discomfort in the pit of my stomach every few days or oftener.
- I am afraid when I look down from a high place.
- Often I cross the street in order not to meet someone I know.
- I do not blame a person for taking advantage of someone who lays himself open to it.
- I often feel that life is not worth the trouble.

MMPI continued

- Before I do something I try to consider how my friends will react to it.
- Several people are following me everywhere.
- I seem to hear things that other people cannot hear.
- I often was in trouble in school.
- People say insulting and vulgar things about me.
- The future seems hopeless to me.
- I gossip a little at times.
- Once in a while I laugh at a dirty joke.

"The Big Five"

Personality Dimensions:

- **Extraversion/Introversion** (sociable or retiring).
- **Neuroticism/Stability** (constantly worrying or calm & self satisfied)
- **Agreeableness/Antagonism** (courteous & trusting or rude & suspicious)
- **Conscientiousness/Undirectedness** (careful or careless)
- **Openness/nonopenness to Experience** (daring or conforming)

Where do Personality Differences Come From?

- Heritability (Variance in personality due to genes): 50% (= First law)
- Shared environment (Variance in personality due to the family): 0 -- 5% (= Second law)

September 7, 1998

Newsweek

**SPECIAL
REPORT
RUSSIA
THE CRISIS IN**

**A New
Heated
Debate
About
How Kids
Develop**

**Do
Parents
Matter?**

\$2.95 US/\$3.95 Canada



Where's the Other 45-50%? (Effects of Nonshared Environment) = Third Law

- Some possibilities:
 - Biological accidents.
 - Social accidents.
 - Parent-child interaction effects.
 - Chance
 - Peers
 - Sibling rivalry

THE



NURTURE

ASSUMPTION

WHY CHILDREN TURN OUT
THE WAY THEY DO

PARENTS MATTER LESS
THAN YOU THINK AND PEERS
MATTER MORE

JUDITH RICH HARRIS

Foreword by Steven Pinker

A painting of five people holding hands on a grassy bank overlooking a body of water with a cloudy sky. The people are dressed in simple, colorful clothing. The sky is filled with soft, white and grey clouds, and the water below is a mix of green and blue tones. The overall mood is peaceful and communal.

BORN to REBEL

*Birth Order,
Family Dynamics,
and Creative Lives*

FRANK J. SULLOWAY

Social, Political, & Moral Issues Surrounding Behavioral Genetics

COME
AND
HEAR

"The quintessential
female is an
individual specialized
for making eggs."
— E.O. Wilson

EDWARD
O. WILSON
Sociobiologist and

The Prophet
of
Right Wing Patriarchy

Tuesday, Oct 9, 1984
4:00 p.m. Auditorium Building
Medical Sciences
BRING NOISEMAKERS

Art Trench

"Our intellectual landscape has been disrupted by the equivalent of an earthquake."
—*Michael Novak, NATIONAL REVIEW*

THE BELL CURVE

Intelligence and Class Structure
in American Life



The
Controversial
New York Times
Bestseller

RICHARD J. HERRNSTEIN
CHARLES MURRAY

With a New Afterword by Charles Murray

What are the Controversial Issues?

- “Genetic Reductionism”
- “Genetic Determinism”
- Justification of inequality
- Abdication of personal responsibility
- Eugenics

A Phony Issue: “Reductionism”

- Bad reductionism vs. Good reductionism
- Levels of analysis (Tinbergen, Chomsky, Marr):
 - What adaptive problem is the organism solving?
 - Ultimate explanation (Tinbergen); Competence theory (Chomsky); Computational theory (Marr)
 - What is the organism doing in real time?
 - Proximate explanation (Tinbergen); Performance theory (Chomsky); Theory of Algorithm (Marr)
 - How is it implemented in biological mechanisms?
 - How did it evolve phylogenetically?
 - How does it develop ontogenetically?

Another Phony Issue: “Determinism”

- Technical meaning of determinism: $p = 1.0$
- Determinism is an *empirical issue*.
 - Huntington’s Disease ($p = 1.0$)
 - Everything else ($0 < p < 1.0$)

A Real Issue: Justification of Inequality



"I don't know anything about the bell curve, but I say heredity is everything."

Possible Innate Differences:

- Among individuals
- Among socioeconomic classes
- Between men and women
- Among races
 - Black-white differences in IQ scores
 - Jews vs. gentiles in ethnocentrism, IQ, shrewdness
 - Afrocentrism: “Ice people” vs. “Sun people”

Issues relevant to Genetics & Inequality

1. Empirical status of genetic hypotheses varies:

- Species: yes
- Individuals: probably (“First Law”)
- Sexes: probably
- Races: probably not
 - Races diverged recently (< 100,000 years ago)
 - Genetic differences are relatively small:
 - 85% among individuals
 - 8% among ethnic groups within a race
 - 7% within a race

Genetics & Inequality, cont.

2. Political equality \neq Biological indistinguishability

Jefferson:

- “We hold these truths to be self-evident: All men are created equal.”
- “There is a natural aristocracy among men. The grounds of his are virtue and talents.”

Genetics & Inequality, cont.

3. All measured group differences are *statistical* (“bell curves”).
4. Even if there are group differences, it would be irrational, & unethical, to discriminate against an *individual* based on the statistics of his or her *group*.

- Ernst Mayr, 1963:

Equality in spite of evident nonidentity is a somewhat sophisticated concept and requires a moral stature of which many individuals seem to be incapable. They rather deny human variability and equate equality with identity. Or they claim that the human species is exceptional in the organic world in that only morphological characters are controlled by genes and all other traits of the mind or character are due to “conditioning” or other nongenetic factors. Such authors conveniently ignore the results of twin studies and of the genetic analysis of nonmorphological traits in animals. An ideology based on such obviously wrong premises can only lead to disaster. Its championship of human equality is based on a claim of identity. As soon as it is proved that the latter does not exist, the support of equality is likewise lost.

- Chomsky, 1970:

A correlation between race and IQ (were this shown to exist) entails no social consequences except in a racist society in which each individual is assigned to a racial category and dealt with not as an individual in his own right, but as a representative of this category. [There may be] a possible correlation between height and IQ. Of what social importance is that? None of course, since our society does not suffer under discrimination by height. We do not insist on assigning each adult to the category “below six feet in height” or “above six feet in height” when we ask what sort of education he should receive or where he should live or what work he should do. Rather, he is what he is, quite independent of the mean IQ of people of his height category. In a nonracist society, the category of race would be of no greater significance. The mean IQ of individuals of a certain racial background is irrelevant to the situation of a particular individual who is what he is. ...

Genetics & inequality, cont.

5. What about the genetically disadvantaged individuals?
 - Rawls, “A Theory of Justice”

Issue # 2: Denial of Responsibility



Man's Genes Made Him Kill, His Lawyers Claim

By Bruce Goldstone
NEW YORK (AP) — A man who shot and killed a woman in a New York City apartment last week is claiming that his genes made him do it, his lawyers said.

The man, 34, was charged with the first-degree murder of a woman, 32, who was shot in the chest and killed in the apartment last week. The man's lawyers said he is a "genetic killer" and that he should not be held responsible for the crime.

The man's lawyers said that he has a "genetic predisposition" to violence, and that this predisposition was "activated" by the stress of the crime. They said that the man's genes "made him kill" and that he should not be held responsible for the crime.

The man's lawyers said that they will fight to have the man's sentence reduced to life in prison without the possibility of parole. They said that the man's genes "made him kill" and that he should not be held responsible for the crime.

LEGAL BATTLE

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Frozen Gene Pool

Scientists now think they've found a gene linked to violent behavior. Think of the implications. We may someday have a cure for hockey.

Genetics & Responsibility

1. Bogus defenses for bad behavior are more likely to be *cultural* than biological:

– The Abuse Excuse, Twinkie defense, Pornography made me do it, Black Rage syndrome, ...

– The Jets:

Dear kindly Sgt. Krupke,

You gotta understand.

It's just our bringing up-ke

That gets us out of hand.

Our mothers all are junkies,

Our fathers all are drunks.

Golly Moses, naturally we're punks!

Genetics & Responsibility, cont.

2. Explanation \neq Exculpation.

– “To understand is not to forgive.”

- Modular mind: limbic system vs. frontal lobes

Issue #3: Eugenics

- “Positive eugenics”:
 - incentives to have children
 - incentives to immigrate
- “Negative eugenics”:
 - penalties for having children
 - restrictive immigration quotas
 - incentives for sterilization
 - mandatory sterilization
 - miscegenation laws
 - murder & genocide

Rise & Fall of Eugenics

- 1900s - 1930s: Popular among progressives
- immigration quotas, mandatory sterilization
 - Oliver Wendell Holmes: “Three generations of imbeciles is enough”
- Nazi holocaust
- eugenics today
 - individual: genetic screening & counseling
 - groups: fringe movement only

Arguments Against Eugenics

1. Denial of human rights
2. Anti-democratic; official stigmatization of citizens
3. Practical difficulties: non-additive variance, time required
4. Limited wisdom, knowledge of decision-makers
5. Excessive powers granted to government