Title: The Genetic Fallacy

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Abstract:

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Evolutionary Psychology (EP)

- Mind is composed of specialized modules

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- *Massive Modularity*: the brain may be composed of hundreds, maybe even thousands, of different modules.

The Genetic Argument

- The Argument: *Humans lack sufficient unique genes to account for massive modularity.*
- Evidence:
  - The human genome comprises only 20,000 genes
  - Humans and chimpanzees have a 98.5% genetic similarity.

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Paul Churchland: "...how-on-Earth to code for the individual connection-places and connection strengths of fully 10^{14} synapses... using the resources of an evolved genome that contains only 30,000 genes, ninety percent of which (all but a paltry 3,000 of which) we share with *mice*..."

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Elman et. al.: Compare, for example, the genome of the chimpanzee, the Old World monkey, and the human. To the layman's (admittedly biased) eye, the Old World monkey and the chimp resemble each other much more closely than either species resembles us. Yet genetically the chimp and the human are almost indistinguishable: We have 98.4% of our genetic material in common, compared with only approximately 93% shared by the chimp and Old World monkey. Humans are closer to chimps, genetically, than chimps are to gorillas. Whatever differences there are between us and the chimp therefore come down to the effects of the 1.6% difference.

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Mazur: With 30,000 genes, only two or three times more than in a fruit fly, the human genome is far smaller than has been suspected. A surprising number of our genes are commonplace, about 10% clearly related to particular genes in the fly and worm. Identities between humans and other animals will become more striking as additional genomes are sequenced.

Marcus: "Language, and whatever else separates us from chimpanzees, has its origins and alterations to no more than about 1.5% of the nucleotides in the genome, a pretty neat trick, when you consider how handy talking can be."

Problems

- Generally, genetics is pretty tricky…
- Specific problems:
  - Genetic underpinning equals more than the sum of one's genes.
  - Humans and chimpanzees differ more than 1.5%

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  - Most changes in species due to changes in gene regulation rather than what genes are coded.

Genetics 101

Central Dogma of Molecular Biology:

DNA → RNA → Polypeptide

DNA:

Double stranded nucleotide chain that is passed from parent to offspring.

RNA:

Single stranded nucleotide chain transcribed (copied) from the DNA

Polypeptides:

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Polypeptides:

Proteins that are translated from the RNA chain using the Universal Code

The Human Genome Project (IHGC)

- Main project was to find the DNA sequence = finding genes
  - 3×10^9 nucleotides
- Secondary project was to find the genes
- Two approaches: (1) *Ab Initio*, (2) *Comparative*
- *Ab Initio*
  - Look for tell-tale signs of where the genes might be
  - GenScan
  - Generally overestimates
- *Comparative*
  - Compare our sequence to genes found in other organisms
  - Ensembl
  - Generally underestimates
- Results:
  - 1999 – 90% of genome sequenced, 30,000-40,000 genes
  - 2004 – 99.9% of genome sequences. 20,000-25,000 genes
  - Compare: 18,000 for nematode, 56,000 for rice
  - Genes are found only on 2% of genome

Genetic Comparisons

- King and Wilson (1975)
- DNA hybrids – temperature of complete separation determined genetic similarity
- Result: humans and chimps have 98.75 genetic similarity
- Supported by subsequent studies.

Most Likely Interpretations

- Very likely that monkeys are our uncles… (genetically speaking)
- Human differences need other, non-genetic explanations

Problems

Genetics 201

New Dogma of Molecular Biology:

DNA → RNAs → Polypeptides

DNA sequences responsible for a plethora of products due to various different mechanisms (we'll only look at a few)

Alternative Splicing

- More than one RNA per gene due to alternative splicing
- Genetics 202: Introns and Exons
- How prevalent is it?
    - On one chromosome, the IHGC found an average of 3.2 alternative splicings for 59% of our genes, v.s. 1.3 alternative splicings for 22% for the worm.
    - Some studies have found hundreds to thousands of alternative variants from one gene.

Polypeptides

- Each polypeptide can be cut up into smaller polypeptides, each serving different functions
- Eg. One study found 9 different proteins being produced from one gene due to polypeptide cuts.

Other phenomena

- Overlapping genes, complex promoters, multiple polyadenylation sites, editing of mRNA, and nested genes

Genetic Similarity

- Counting *indels*, two recent studies have shown that we differ from chimpanzees more than previously estimated:
  - The latter shows a difference of 13%
  - Bioinformatics technique

- Problems with previous interpretation: 1.5% genetic divergence doesn't mean 1.5% novel genes, but 1.5% difference in *each gene*.

Non-Gene Differences

- Genetics 203 – coding vs. regulatory regions
- Most of the human genome, possible 1/3 of it, is regulatory
- Species difference may be due more to regulatory differences rather than coding ones.
- Although we share most amino acids, one study found more expression differences in brains of humans than livers.

Conclusion

- Very likely that *genomic* differences are greater than a simple interpretation would show.
- What's in a gene?
- Status of EP:
  - Not claiming that it is now preferable over other cognitive theories
  - Simply that we cannot make any conclusion over its status (yet) based on genetic findings.