Intelligence and Cognitive Functioning
Chapter 13

The Nature of Intelligence
The Biological Origins of Intelligence
Deficiencies and Disorders of Intelligence
The Nature of Intelligence

Figure 13.2: Distribution of IQ Scores in the Population

- Intelligence: ability to reason, understand, profit from experience.
- Intelligence quotient (IQ)
  - 100 average. *Original tests were designed for children.
  - *High Positive correlation to school performance, and lower (but still positive) correlation to job performance, income, socioeconomic level
- Negatively correlated to Juvenile delinquency
- Note that only a VERY small proportion of the population tests outside of the ‘normal’ range. *Only 2% above 130 or below 70.
The Nature of Intelligence

• The Structure of Intelligence
  • Tests help define what we mean, however they have issues: Hard to make one that is ‘culture free’ and that doesn’t rely on verbal skills / abilities (like the *Raven Progressive Matrices, which is a more accurate measure of ‘pure’ intelligence’).
  • Debate whether intelligence is a single capability or a collection of abilities
    • Lumpers- single ability (Spearman’s ‘g’ factor)
    • *Splitters- collection of abilities, unrelated to each other
    • *Most tests can’t or don’t measure things like ‘street smarts’.
• The Brain and Intelligence
  • Einstein
    • Slightly smaller brain, but relatively larger parietal lobes, that also had more glia in *left parietal- an area related to mathematical ability and spatial reasoning.
    • Active, distributed network is present in “intelligent” individuals
• Brain Size *(we have a large brain to body ratio)*

• General intelligence correlates with:
  • Gray matter volume (particularly frontal areas)
  • Brain organization- thicker cortex, smaller columns
The Biological Origins of Intelligence

Figure 13.5: Areas Where Cortical Thickness Is Associated With Intelligence.
The Biological Origins of Intelligence

Figure 13.6: Relationship Between IQ Scores and Nerve Conduction Velocity

- IQ scores correlated with processing efficiency
  - Higher myelination
    - Increased nerve conduction and processing speed
    - Reduces “cross talk” to adjacent areas
The Biological Origins of Intelligence

Figure 13.7: Greater Efficiency in the More Intelligent Brain

- *Women’s smaller brains are more efficient
- IQ scores correlated with processing efficiency
  - Higher myelination
    - *Increased nerve conduction velocity and processing speed
    - reduces “cross talk” to adjacent areas
  - *Reduced energy (glucose) use (b)
The Biological Origins of Intelligence

Figure 13.8: Brain Locations Involved in Mathematical Performance

- Specific abilities and the brain
  - Linguistic:
    - *left frontal, temporal lobes
  - Logical-mathematical
    - Left prefrontal cortex (rote calculation)
    - Parietal cortices (active calculation).
  - *Mirror neurons: unique to humans & primates
  - Spatial
    - Right parietal structures.
The Biological Origins of Intelligence

Figure 13.9: Correlations of IQ Scores Among Relatives

• Heredity and Environment
  • Heredity at 41%, and increases with age
  • Genes: ASPM (brain size), PACAP (neurogenesis)
  • Identical twins reared apart more similar than fraternal twins raised together
The Biological Origins of Intelligence

• The Genetic Controversy
  • Whether ethnic differences in intelligence are genetic (hereditarian perspective)
  • Evidence for:
    • Identical twins raised apart have more similar IQ scores than adopted environments (i.e., Fig 13.9)
  • Evidence against:
    • Socioeconomic status a stronger factor than ethnicity
    • APA task force found no direct evidence of IQ differences between African Americans and Caucasian Americans
The Biological Origins of Intelligence

Figure 13.11: Worldwide Relationship Between Intelligence and Infectious Disease

- Environmental effects
  - Socioeconomic level and parental education (genetic confounds)
  - Environmental interventions
    - Head Start (temporary), *Abecedarian Project (earlier in life, more permanent)
  - Level of infectious disease best predictor of global differences
The Biological Origins of Intelligence
Application: Enhancing Intelligence and Performance

• Nature poll: 20% of respondents had used drugs to enhance concentration or memory.
• “Smart drugs” in use now include:
  • Modafinil and methylphenidate for alertness, learning
  • Dopamine agonists (d-amphetamine) for working memory
• Electrical stimulation of prefrontal cortex, and working memory training tasks also improve performance.
Deficiencies & Disorders of Intelligence

Figure 13.12: Compensatory Brain Activity in High-Performing Older Adults

• Effects of Aging on Intelligence
  • Perceptual speed drops after 25
  • Numeric memory at 60.
  • **Default mode network** is responsible for preparedness for action
    • Encompasses portions of the parietal, frontal and temporal lobes
  • Nonphysical causes
    • Lack of skill practice, low self esteem, poor diet
  • Sex hormones can provide protection against the cognitive effects of aging
    • Testosterone replacement in males improves spatial memory, and if we use dihydrotestosterone we can also get working & verbal memory improvements.
Deficiencies & Disorders of Intelligence

• **Intellectual disability** is a limitation in intellectual functioning and in adaptive behavior originating before the age of 18.

  • The criteria for intellectual disability are an IQ below 70 and difficulty meeting routine needs like self-care. Most cases fall in the ‘mild’ range, and *they can live independently.

  • This definition and the categories of disability are arbitrary and likely to change in the future.

  • Most cases of disability are due to a combination of genetic and environmental causes.

  • Environmental causes include disease during infancy, *low* socioeconomic status, prenatal exposure to viruses, and *maternal alcoholism.
# Deficiencies & Disorders of Intelligence

Table 13.1: Categories of Intellectual Disability

<table>
<thead>
<tr>
<th>Category</th>
<th>IQ</th>
<th>Percentage</th>
<th>Adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>50–70</td>
<td>85</td>
<td>Educable to sixth-grade level; may be self-supporting as adult, with assistance.</td>
</tr>
<tr>
<td>Moderate</td>
<td>35–49</td>
<td>10</td>
<td>May achieve education to second-grade level, live outside institution with family, and contribute to support.</td>
</tr>
<tr>
<td>Severe</td>
<td>20–34</td>
<td>4</td>
<td>Verbal communication and ability to profit from vocational training are limited.</td>
</tr>
<tr>
<td>Profound</td>
<td>Below 20</td>
<td>1</td>
<td>Little or no speech. Requires constant care and supervision.</td>
</tr>
</tbody>
</table>
• **Down syndrome** (Extra 21\textsuperscript{st} chromosome)
  • *Leading genetic cause of intellectual disability.*
  • Glia secrete less of two proteins that support neuron survival.
  • Increasing proteins in women with Down syndrome fetus might be an effective treatment.
Deficiencies and Disorders of Intelligence

- **Fragile X syndrome**
  - Mutated FMR1 gene, role in pruning excess synapses.
  - More likely in males, milder in females.

- **PKU (Phenylketonuria)**
  - Lacks enzyme that breaks down phenylalanine (amino acid).
  - Avoidance of high phenylalanine foods prevents intellectual impairment.

- **Hydrocephalus**
  - Fluid buildup in ventricles, reducing brain tissue amount.
    - Treated by using a shunt to drain excess fluid.
    - 50% of hydrocephalics with 5% brain capacity have IQs over 100.
Deficiencies & Disorders of Intelligence

- **Autism Spectrum Disorders (ASD)**
  - *Social deficits, communication difficulties and repetitive behaviors*
  - Impaired communication, imagination and socialization
  - Lack a **theory of mind** (infer another’s thoughts based on experience)
  - *Lack of Empathy may be due to deficient mirror neurons*
Deficiencies & Disorders of Intelligence

Figure 13.16: Savant-Like Ability Following Brain Impairment

• **Autistic Savants** and High-Functioning individuals with ASD
  • Savant: 1+ exceptional skills but overall low functioning
  • High-functioning: impairment overcome with effort (Temple Grandin)
  • Skill source perhaps due to compromised executive or integrative function
Deficiencies and Disorders of Intelligence

- Brain anomalies
  - Disorder of brain development
    - Brain stem, Cerebellum, Temporal lobes
  - Lack of amygdala and ventromedial prefrontal cortex (vmPFC) coordination
    - Avoidance of looking at faces
    - Problems tracking objects
  - Decreased mirror neuron activity due to reduced activity in the dorsal stream inputs to frontal and motor cortices.
  - Decreased white matter
    - Loss of synchronized activity
Deficiencies & Disorders of Intelligence

Figure 13.19: Reduced Response to Betrayal of Trust Following Oxytocin.

- Biochemical Anomalies
  - Abnormal levels of serotonin, glutamate, GABA, and oxytocin
  - *Low oxytocin and serotonin levels appear to be associated with impairments in sociability
Deficiencies & Disorders of Intelligence
APPLICATION: Childhood Vaccines and Autism

- Environment and ASD
  - Traffic pollution can disrupt brain development
    - Reduces energy to developing brain
  - Maternal metabolic conditions
    - Obesity, diabetes, and hypertension linked to ASD
    - Folic acid supplements reduce risks.
  - Childhood vaccines have NO link to ASD
Deficiencies & Disorders of Intelligence

• Heredity
  • Siblings of ASD children 25 times more likely to develop the disorder
  • *Concordance rates over 90% if we include social and behavioral disorders along with Autism
  • ASD genes expressed in superficial cortex, interfering with connections
  • Absence of genes in frontal and temporal cortices of ASD individuals indicate a possible epigenetic influence.
  • ASD twice as common in boys
Deficiencies & Disorders of Intelligence

- **Attention deficit hyperactivity disorder (ADHD)**
  - Characterized by
    - Impulsiveness
      - inability to sustain attention
    - learning difficulty
    - hyperactivity.
  - Neurotransmitter Anomalies
    - Reduced dopamine pathway activity (impaired reward)
    - Ritalin (stimulant)
      - Increases norepinephrine output to the prefrontal cortex
      - Improves impulse control, working memory, and learning
Deficiencies & Disorders of Intelligence

Figure 13.21: The ADHD Brain

- **Attention deficit hyperactivity disorder (ADHD)**
  - Brain anomalies
    - Reduced Prefrontal cortex, Cerebellum, and Right caudate nucleus of the striatum
    - Disruption of attention-inhibition network of temporal, inferior parietal
Deficiencies & Disorders of Intelligence

• **Attention deficit hyperactivity disorder (ADHD)**
  
  • Heredity
    
    • *5-6 times more prevalent in relatives than non-relatives
    
    • Concordance: 79% in identical twins, 32% in fraternal twins.
    
    • Genes involved in
      
      • Dopamine, norepinephrine, and serotonin transmission
      
      • Synaptic functioning
      
      • Neural development and survival
      
      • Learning
Deficiencies & Disorders of Intelligence

Figure 13.20: Relative Odds of Avoiding Substance Abuse Disorder in Individuals Receiving Stimulant Treatment for ADHD as Children, Compared to Those Not Receiving Stimulant Treatment.

- The Environment and ADHD
  - ADHD incidence increased by
    - Stress, smoking, drug abuse during pregnancy
    - Brain injury, stroke, and pregnancy/birth complications
    - Lead and pesticide exposure
  - Early ADHD drug treatment might prevent later substance abuse