Intelligence

Follow up from last week:
https://www.nytimes.com/interactive/2018/05/16/upshot/audio-clip-yanny-laurel-debate.html#k=-0.228
Overview

• What is intelligence?
  – The origins of intelligence
  – Theories of intelligence: one thing or many

• Factors that influence intelligence
  – Genetics & Environmental factors
  – Cognitive factors
  – Brain measures
  – Brain training
How do YOU define intelligence?

• Is it the ability to use reason and logic?
• Is it the ability to write and speak clearly?
• Is it limited to one’s performance in school?
• Is it behavior in social situations?
• How about knowing when you’re wrong?
One definition

• (Gottfredson, 1997): “The ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly, and learn from experience”
Who is the smartest?

Ken Jennings
(Renowned Jeopardy player)

Neil deGrasse Tyson
(astrophysicist)

Judit Polgár
(one of the best Chess players)

Marilyn vos Savant
(one of highest IQs ever recorded)
What is Intelligence Anyway?

- Key question: is it 1 thing or many?
  - From beginning, IQ measured by multiple tests
  - Modern IQ tests split scores on multiple test (e.g. verbal and performance scores) but then combine into 1 score

- Many difference answers to this question
Early approaches to Intelligence

• Sir Francis Galton (1822-1911)

• Intelligence as a function of psychophysical abilities: e.g. weight discrimination, pitch sensitivity

• Inspired by Darwin, argued that human mental abilities just like many physical characteristics are inherited
  – Analyzed family trees to show how generations of families produced eminent people

(1869): “Hereditary genius: An inquiry into its laws and consequences” that inspired the eugenics movement
Alfred Binet

- Early 1900s, France needed help in its public schools
- Wanted to identify children who needed remedial education
- Developed Binet-Simon Intelligence scale that would predict children’s future progress in Paris school system
- Binet believed that intelligence was complex and could not be fully captured by a single quantity and that intelligence is not fixed

1857 - 1911
Stanford-Binet Intelligence Scales

- Stanford Psychologist Lewis Terman brought IQ testing to U.S.
- Led to first definition of intelligence quotient (Stern, 1912) based on mental age

\[
\text{Intelligence Quotient (IQ)} = \frac{\text{mental age}}{\text{chronological age}} \times 100
\]

e.g., Child performs at 11 year old level but is 10 years old
IQ = 11 / 10 x 100 = 110
Terman’s Gifted Children Study

• In 1921, Terman picked 1,528 gifted kids (with IQ > 135 of higher)

• Followed them throughout their lives

• More likely than other children to do well in school, publish important papers, patent inventions, and earn high incomes

• Terman’s conclusion: IQ test is a valid test of intelligence because it predicts performance on tasks that require high intelligence
Weschler Intelligence Scales (WAIS and WISC)

- IQ score is based on the deviation of person’s score from the norms of the person’s age group

\[
IQ = \frac{\text{raw score} - \text{mean}}{\text{standard deviation}} \times 15 + 100
\]
Wechsler Adult Intelligence Scale (WAIS)

**VERBAL**

**General Information**
What day of the year is Independence Day?

**Similarities**
In what way are wool and cotton alike?

**Arithmetic Reasoning**
If eggs cost 60 cents a dozen, what does 1 egg cost?

**Vocabulary**
Tell me the meaning of corrupt.

**Comprehension**
Why do people buy fire insurance?

**Digit Span**
Listen carefully, and when I am through, say the numbers right after me.

```
7 3 4 1 8 6
```

Now I am going to say some more numbers, but I want you to say them backward.

```
3 8 4 1 6
```

**PERFORMANCE**

**Picture Completion**
I am going to show you a picture with an important part missing. Tell me what is missing.

```
'85
SUN  MON  TUE  WED  THU  FRI  SAT
1  [2]  3  4  5  6  7
8    9 10 11 12 13 14
15   16 17 18 19 20 21
22   23 24 25 26 27 28
29   30
```
Picture Arrangement
The pictures below tell a story. Put them in the right order to tell the story.

Block Design
Using the four blocks, make one just like this.

Object Assembly
If these pieces are put together correctly, they will make something. Go ahead and put them together as quickly as you can.

Digit-Symbol Substitution

<table>
<thead>
<tr>
<th>Code</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>△ 8 × O △ □ 8 × △ 8</td>
</tr>
</tbody>
</table>
How good are IQ tests?

• **Reliability**
  – Evidence suggests good test-retest reliability

• **Validity**
  – Harder question
  – Need to avoid circular definitions
    • Critique of intelligence tests by Boring (’23):
      “Intelligence is what these tests measure”
Predictive Validity

• IQ correlates with:
  – Later GPA
  – Work Success, $ 
  – Longevity

• Correlations modest (around 0.5)

Illustration of different correlations
Is intelligence one thing or many?

• Different theories have been proposed
  – Spearman’s g
  – Fluid and crystallized intelligence
  – Sternberg tripartite theory
  – Gardner’s multiple intelligences
Spearman’s $g$

- Spearman proposed a two-factor theory of intelligence, emphasizing a general factor ($g$) and one or more specific factors ($s$).
- Knowing a person’s $g$ allows predictions of performance on other tasks.
Catell: Fluid & Crystallized g

- **Fluid g:**
  - ability of deal with new & unusual problems
  - Mental speed & flexibility

- **Crystallized g:**
  - Repertoire of acquired skills & information

- Developmental changes
Sternberg’s Tripartite Theory

• Practical Intelligence
  – Often seen in business: find effective solutions to problems ("street smarts")

• Analytic Intelligence
  – Measured most often by IQ tests

• Emotional intelligence
  – Ability to perceive and understand emotions, as well as to use emotions to facilitate thinking
Broader Theory of Intelligence

- Howard Gardner posited 8 types of intelligences
  - Linguistic
  - Logical-mathematical
  - Spatial
  - Musical
  - Bodily kinesthetic
  - Interpersonal
  - Intrapersonal
  - Naturalistic
  
  Part of previous theories
How much is intelligence determined by genetics?

• Problem is that genetics & environment are naturally confounded

• In normal circumstances, people grow up with people they are related to

• Exceptions:
  – adopted children
  – identical (monozygotic/MZ) twins reared apart
Monozygotic vs. Dizygotic

Share 100% of their genes

Share ~50% of their genes
Teasing Apart Nature & Nurture

What does this comparison tell us?

IQ correlation

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Raised together</th>
<th>Raised apart</th>
<th>Adoptive</th>
<th>Raised together</th>
<th>Raised apart</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genetic relatedness</td>
<td>P-O</td>
<td>Sib</td>
<td>P-O</td>
<td>Sib</td>
<td>P-O</td>
</tr>
<tr>
<td>Same home?</td>
<td>.5</td>
<td>.5</td>
<td>.5</td>
<td>.5</td>
<td>0</td>
</tr>
</tbody>
</table>
Environmental Effects

Differences in intelligence among these groups are largely environmental, as if one environment is more fertile in developing these abilities than another.

Example: Height is 90% heritable – Still, Japanese men are 3 inches taller in US than in Japan
Importance of Environment

• Socioeconomic status
  – Being adopted from a low SES to a high SES family increases IQ by 12 to 18 points

• Schooling
  – Years of missed school -> lower IQ
  – Enrichment and education -> higher IQ

• Exposure to language
  – variation in children’s IQ and language ability related to amount parents speak to children
Flynn Effect: worldwide increase in IQ over time

Intelligence test scores, based on 1996 standards

Rising average intelligence test performance
Cognitive Basis of Intelligence

• Speed of mental processing:
  – High IQ related to fast response times

• Role of working memory
  – High IQ related to performance on challenging working memory tasks

• Importance of attentional/cognitive control
  – Ability to solve multiple tasks simultaneously
Brain Basis of Intelligence

- **Brain size**
  - Correlation 0.4 between overall brain size and IQ

- **Brain function** (degree of activation)
  - Intelligence arises from the interaction of a distributed set of brain regions, primarily comprising regions in **frontal and parietal cortices**.

- **Brain structure**
  - White matter (axons)
  - Gray matter (neuronal cell bodies)

- Caution: these are correlational studies
Raising your IQ through Brain Training?

• Can we increase fluid intelligence by training?

• Experiments by Susanne Jaeggi (Now at UC Irvine) showed that extensive working memory training can improved fluid intelligence scores

• However....hard to find evidence for long-lasting effects that transfer to real-world effects