What is intelligence?

Critique of intelligence tests by Boring ('23):
“intelligence is what these tests measure”

Who should have high intelligence? Some seemingly smart people such as Chess masters do not have higher than average IQ.

Does IQ relate to anything?

However, intelligence tests do predict performance in education. Tests are useful to some degree.

Three issues:
how to measure intelligence?
how many kinds of intelligence are there?
how do we explain individual IQ differences?
How to measure intelligence?

- You arrive in a country that has two types of people: truth tellers and liars. The truth tellers always tell the truth, and the liars always lie.

- Your tour guide, a native, tells you that the country's prime minister just admitted being a liar. Is your tour guide a liar or a truth teller?

**History (1)**

Galton (1822-1911):

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

Large individual differences, but these do not predict differences in scholastic performance.
History (2)

• Binet (1857 – 1911)
  - Developed procedure for predicting school success.
  - Introduced concept of mental age

Age Two
1. Copy into Pencil Board: Placing three geometric objects in tern board.
4. Block Building: Building four block tower by stacking remaining blocks.
5. Picture Composition: Completing a drawing from a blank.

Age Six
1. Vocabulary: Correctly defining 8 words on 40-word list.
2. Differences: Identifying difference between two objects.
3. Matching Pictures: Matching out missing part of pictured object.
5. Opposite Analogies & Terms of time: "Summer is not winter is _____________."

Age Ten
1. Vocabulary: Correctly defining 11 words on same list.
2. Block Counting: Counting number of cubes in three-dimensional picture.
3. Abstract Words: Definition of abstract attributes.
4. Figure Recognition: Giving names for clues of preferences.
5. Word Naming: Naming as many words as possible in one minute.

First definition of IQ

• Stern (1912).

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

What is the problem with this definition?

Modern IQ score:

\[ \text{IQ} = 100 + \left( \frac{\text{score} - \text{mean}}{\text{standard deviation}} \right) \times 15 \]
Different approaches

• Cognitive factors/ psychometrics/ factor analysis approach

• Cognitive correlates/ Cognitive components

• Cognitive training

Factor Analysis of Intelligence

• Separate intelligence into hypothetical factors

Example test battery

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Reading Comprehension</td>
<td>Answer questions about paragraph</td>
</tr>
<tr>
<td>2. Vocabulary</td>
<td>Choose synonyms for a word</td>
</tr>
<tr>
<td>3. Grammar</td>
<td>Identify correct and poor usage</td>
</tr>
<tr>
<td>4. Quantitative Skills</td>
<td>Read word problems and decide whether problem can be solved</td>
</tr>
<tr>
<td>5. Mechanical reasoning</td>
<td>Examine a diagram and answer questions about its requires knowledge of physical and mechanical principles</td>
</tr>
<tr>
<td>6. Spatial Reasoning</td>
<td>Indicate how two-dimensional figures will appear if they are folded through a third dimension</td>
</tr>
<tr>
<td>7. Mathematics Achievement</td>
<td>A test of high-school algebra</td>
</tr>
</tbody>
</table>

Which of these tests measure the same underlying ability/ hypothetical factor?
Observed Correlations

Measure correlations between scores on different tests. Can we observe any interesting patterns in these correlations to tell us which tests measure the same thing?

<table>
<thead>
<tr>
<th>Test no.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
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<td>1.00</td>
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</tbody>
</table>

A 2D spatial layout of the tests based on the observed correlations – nearby located tests have high correlations

Factor analysis: interpret the clusters

- 1. Reading comprehension
- 2. Vocabulary
- 3. Grammar
- 4. Quantitative skills
- 5. Mathematical knowledge
- 6. Spatial reasoning

- Group into the factor “Linguistic ability”
- Group this as “Reasoning ability”
- Call this “Spatial ability”
Problem: there are many ways to interpret the correlations, involving few or many factors. Group these as "Linguistic ability" and now call this one group: "Reasoning ability".

Factor Analyses of Intelligence
- Spearman (1863 – 1945):
  - general factor of intelligence (mental energy): $g$
  - Specific factors (arithmetic, reasoning, etc.)
- Thurstone (1938): seven primary mental abilities

Cognitive Correlates/ Components
- Explain individual differences in terms of differences of *information processing* capabilities
- Stresses speed and accuracy in simple tasks
- Hunt et al. (1975): verbal ability might be related to lexical access speed
Hunt et al.'s Task
Physical identity: “A-A” same, “A-a” different
Name identity: “A-a” same, “A-B” different

Cognitive Components (Sternberg, 1977)

A : B :: C : ?
LAWYER : CLIENT :: DOCTOR: ____

Sternberg proposed some hypothetical processes to complete analogy:
1. Encode each term A,B,C, and D
2. Infer relationship between A and B
3. Map relationship to C
4. Apply relationship to C

How to measure the time it takes to complete each hypothetical process

Sternberg assumed additivity and independence.

The idea is to run experiment multiple times but under different conditions that might involve different subsets of processes.

<table>
<thead>
<tr>
<th>Cond 1</th>
<th>Cond 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>t₁</td>
<td>t₂</td>
</tr>
<tr>
<td>t₂</td>
<td>t₁</td>
</tr>
<tr>
<td>t₃</td>
<td>t₄</td>
</tr>
</tbody>
</table>

T₁ = observed total time for cond1 = t₁ + t₂ + t₃ + t₄
T₂ = observed total time for cond2 = t₂ + t₃ + t₄

Estimated time for hypothetical process (1) = T₂ – T₁
Relate estimates for individual processes to different tests
• Sternberg estimated the time it took to complete the individual processes.
• Obtained estimates for many participants.
• He then correlated the estimated processing times for the individual components with performance on reasoning tasks and perceptual tasks.
• Outcome: some components relate to overall reasoning ability, others do not

Results of component research
• Analogy results:
  – Higher intelligence → faster analogy solving
  – Higher intelligence → slower on encoding, but much faster on other components
• In general:
  – higher intelligence → more global planning, less time local planning
  – Higher intelligence → more research in writing papers, less time writing the papers

Cognitive Training
Complete the following letter series:
1. atbataatbat ___
2. aaabbbccddd_____ 
3. wxaxybyczadab ____
4. urtustuttu______

Train on detection of interletter relations, discovery of periodicity, completion of pattern description, extrapolation
Cultural Context

• Kpelle tribe: refuse to categorize animal names

• Italian Americans 100 years ago: IQ=87, now IQ>100

• Western culture: intelligence = quickness. What about deliberate judgment?

• Are there culture fair tests?