

Psyc 101, Pomerantz
Section 9: Intelligence

Intelligence: what is it?

Think about the most intelligent person you've ever known. What are his/her characteristics?

Some elements of intelligence:

Book smarts: Rice students do well on this!

Street smarts: encountering the bear

Creativity: artistic genius

The ability to comprehend; to understand and profit from experience (Wordnet)

A general mental capability that involves the ability to reason, plan, solve problems, think abstractly, comprehend ideas and language, and learn. In psychology, the study of intelligence is related to the study of personality but is not the same as creativity, personality, character, or wisdom (Wikipedia)

An analogous problem: who has the "smarter" PDA (superior computer, better car, more desirable partner, etc.), you or your roommate? Relevant factors for PDA might include:

CPU speed

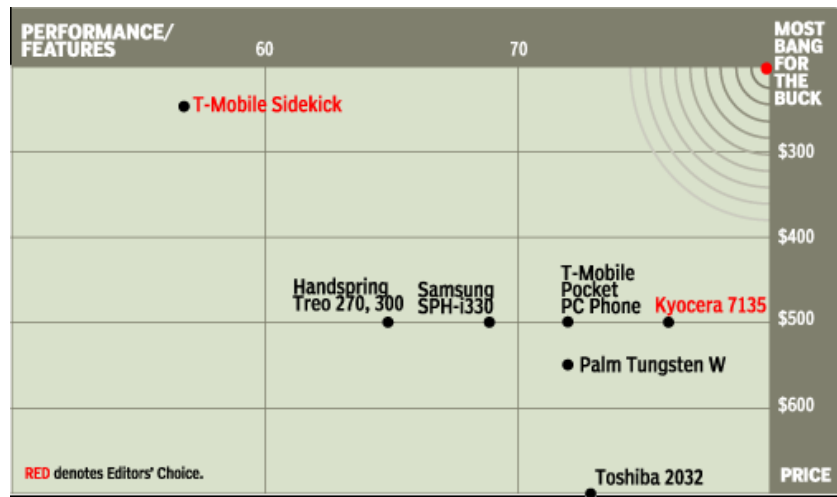
Storage capacity

Video performance

Audio performance

Frequency of crashes/ reboots

Benchmark performance on various tasks: number crunching, graphics, etc.



Here, a variety of indices are combined to assess performance, but it's more of an art than a science.

Big question: how much weight do you give to each factor in your overall assessment?

When assessing human intelligence, there is a similar range of factors to include.

Strategy for deciding how to measure intelligence:

- Enumerate all the factors that seem to figure into intelligence and include them in your mix
- Validate your test battery against some ultimate criterion, e.g., success in life, on the premise that intelligence is what leads to success.
- Major question: what is success in life?
- Eliminate factors that do not predict this criterion
- The test must be both reliable and valid
- Note that intelligence should measure ability, not just achievement (i.e., how capable you are of learning and reasoning, not how much information you've already processed). Thus a knowledgeable adult may score as less intelligent than a mere child if the child can acquire new information more quickly and accurately.

So, what IS intelligence?

- The ability to solve problems well and to understand and learn complex material. (Note: the latter is needed to avoid "ceiling effects")
- The ability to adapt to the environment and its changes
- The speed with which problem solving, understanding, and adaptation occur
 - Sometimes intelligence is manifested by slow, deliberative mental processing (cf., speed/accuracy tradeoffs)
 - Nevertheless, most intelligence tests are timed
 - Consider the correlation between time spent studying for a test and performance on the test: is it positive or negative?
- Operational definition: intelligence = score on an intelligence test

The beginnings: Alfred Binet in France (1857-1911) (w/ Theodore Simon)

- Motive: to identify school children needing extra help
- Strategy: construct a test with many different types of tasks that seem to tap intelligence (Binet-Simon test)
- Norm the test (i.e., administer it to a wide range of individuals varying in age, gather statistics)
- Compare a child's mental age (MA) with his/her chronological age (CA)
 - Later, from William Stern: $IQ = \text{intelligence quotient}, 100 * (MA/CA)$
- This scale is problematic because MA reaches asymptote whereas CA marches on

Thus, intelligence testing evolved for practical applications.

Next, Lewis Terman at Stanford, 1916

- Stanford-Binet revision of Binet-Simon test
- Still used today
- Appropriate for ages 2 - adult

WWII and the Army Alpha test: more practical applications

- Below chance scoring on the Alpha

Weschler Adult Intelligence Scale (WAIS)

Weschler Intelligence Scale for Children (WISC)

- The most widely used tests in the US today
- Puts less emphasis on verbal skills than does Binet's test
- Puts greater emphasis on non-verbal skills (e.g., arranging pictures in a meaningful order)

Note complications for people who are blind, cannot write, etc.

Questions similar to those on the WAIS-III:

Verbal Subtests

Information: Who wrote *The Great Gatsby*

Comprehension: What does it mean when people say "Birds of a feather flock together"

Arithmetic: If you paid \$8.50 for a movie ticket and \$2.75 for popcorn, how much change would you have from a \$20 bill?

Similarities: In what ways are airplanes and submarines alike?

Digit span: repeat back the following numbers: 3 2 7 5 9

Vocabulary: What does emulate mean?

Performance Subtests

Digit symbol-coding: The examiner presents a key that matches digits (e.g., 1, 2, 3) with symbols (e.g., Φ , Ψ , Θ). The test taker uses the key to complete a chart that gives just digits or just symbols

Picture completion: The test taker examines a picture and says what is missing (e.g., a horse without a mane)

Block design: The test taker uses patterned blocks to reproduce designs provided by the examiner

Picture arrangement: The test taker puts a series of cartoon-like pictures into order so that they tell a story

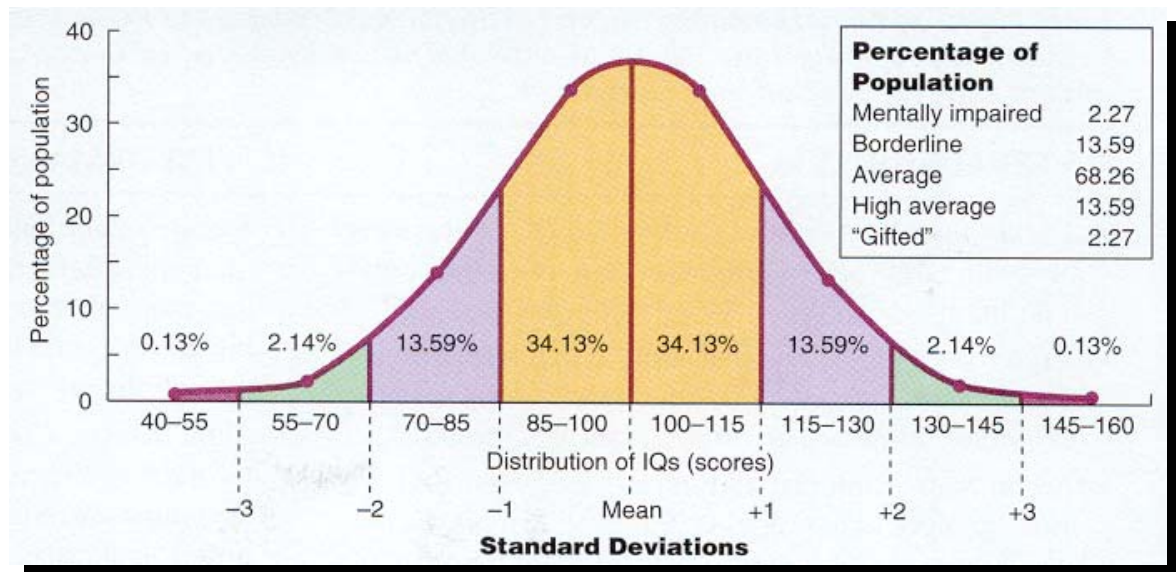
Object assembly: The examiner gives the test taker a set of cardboard puzzle pieces. The test taker arranges the pieces to form a picture of a common object.

With the WAIS, intelligence is not IQ but is total score on the test. These scores tend to be normally distributed. Thus...

Intelligence Scores and the Bell Curve

Normal distribution: result of Bernoulli process: the net result of a series of independent events or trials (cf. counting the number of "heads" in a classroom of people flipping coins 200 times). Similarly, intelligence may be the result of a large series of events at both the biological (genetic) and environmental (cultural) level.

Scores are normed, i.e., scaled to have a mean of 100, standard deviation of 15.



To create this scale, we start with a *standardized sample*: a random sample of people chosen from the appropriate population (i.e., a group of people sharing specified characteristics, such as people living in the United States who are functioning at least minimally, i.e., not in a coma, etc.)

Reliability and Validity: both are critical. Recall that:

- Reliability means repeatability with same outcome
 - Test-retest reliability
 - Split-half reliability
- Validity means that the test measures what it is supposed to measure.
 - Face validity: plausibility on the surface
 - Content validity: thoroughness, measuring all aspects
 - Criterion validity: correlates well with some ultimate measure
 - Construct validity: measures each assess variables specified by a theory

Validity: People with high intelligence scores

- Earn higher GPAs in high school and college (especially high verbal)
- Experience higher job success
- Earn high salaries in higher-prestige positions
- Enter into more stable marriages and stay out of jail
- Live longer (cf. "Darwin Awards")

But: only about 25% of *variance* in levels of job success can be predicted by IQ scores (recall the meaning of variance)

Psychometric approach: how many components are there to intelligence?

Ask 10 people to rate the taste of apples, on a scale from 1 (bad) to 10 (great)

	Big	Small	Mean
Red	40	80	60
Green	20	60	40
Mean	30	70	50

Variance = sum of squared deviations of numbers about their means

$$\begin{array}{l} 40 - 50 = 10, 10^2 = 100 \\ 20 - 50 = 30, 30^2 = 900 \\ 80 - 50 = 30, 30^2 = 900 \\ \underline{60 - 50 = 10, 10^2 = 100} \\ \text{Variance} \qquad \qquad \qquad 2000 \end{array}$$

Statistical technique: divide this 2000 in to components.

Because there are four numbers here, there are 3 possible components (degrees of freedom):

- One for size
- One for color
- One for the interaction of size with color (e.g. size matters more for green than for red)

Between size and color, size accounts for more of the variance.

Charles Spearman (1927): performed a psychometric analysis of intelligence scores looking for correlations. Logic:

- test items whose scores are perfectly correlated over people are therefore testing the same component of intelligence
- test items whose scores are uncorrelated are testing totally different components
- many/most items will show intermediate correlations, neither zero nor +/- 1.0
- so, take a large set of items and perform *factor analysis* on them.

Result:

- One general factor that is shared over items (shared variance, the extent to which all test items rise and fall together)

- Several specific factors, *s*, that are not shared (rise and fall in an uncorrelated fashion)
- Thus Spearman's contribution: a positive correlation over many test items indicates the existence of a single underlying intellectual factor
 - “*g*”: general factor
 - “*s*”: specific factors, indicated by variations in correlations over factors
 - Performance on any one item depends on both *g* and *s*
 - Overall intelligence, however, appears to depend mostly on *g*
 -
- Louis Thurstone (1938): developed a battery of 56 tests
 - He analyzed the correlations over people across these tests using *Factor analysis*: a statistical technique
 - Thurstone then identified seven “primary mental abilities” (e.g., verbal comprehension, spatial visualization)
 - Later pursued by Carroll (over 70 factors) and Guilford (over 100 factors)
- Raymond Cattell (1971): Analyzing the *g* factor into components.
 - Crystallized intelligence (relies heavily on previous knowledge)
 - Fluid intelligence (relies on ability to solve new problems)
 - With aging, crystallized intelligence doesn't suffer
 - Fluid intelligence tends to decrease, however

Modern Synthesis of all these Ideas:

- Most psychologists agree there exists something like Spearman's *g*.
- They also believe in *s* factors.
- Big debate: what is *g*, and what does it mean?

Interesting observation:

- People scoring high on IQ show sharp disparities on their scores on subscales. I.e., bright people tend to have some areas where they are truly bright and other areas where they are not bright but totally average
- People scoring low on IQ show few disparities: they are generally uniform in their lack of strengths.
- Cf. “happy families are all alike; every unhappy family is unhappy in its own way,” Leo Tolstoy, *Anna Karenina*
- One possible explanation: *g* is required to create spikes of intelligence in particular areas; w/o a high *g*, there are no spikes (thus, a uniformly low profile)

- Howard Gardner: there are 8 or 9 forms of intelligence working together, not in isolation

- Linguistic intelligence
- Spatial intelligence
- Musical intelligence
- Logical-mathematical intelligence
- Bodily-kinesthetic intelligence
- Intrapersonal intelligence
- Interpersonal intelligence
- Naturalist intelligence
- Existential intelligence (tentative): ability to address the “big questions” about existence

People are characterized by their profiles across these 8/9 dimensions

- Robert Sternberg (3 forms of intelligence)

- Analytic intelligence: reading, writing, math abilities. Basically, IQ
- Practical intelligence: fixing cars, other implicit memory tasks. This factor seems to include EQ (emotional intelligence); see below.
- Creative intelligence: formulate novel solutions (requires at least an average analytical intelligence)

Learning is maximized if people are taught in a way that is compatible with their strongest form of intelligence.

- Emotional Intelligence

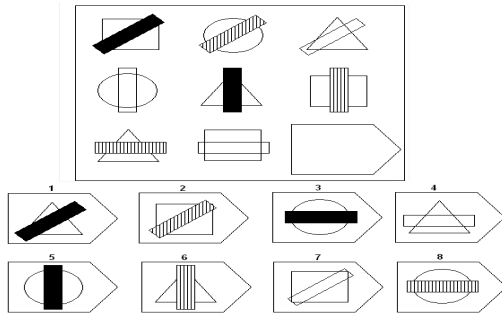
Includes some overlap with practical intelligence

- Managing your feelings (e.g., noticing you are becoming annoyed, counting to 10 to calm down)
- Understanding your emotions (e.g., knowing your friend is jealous of someone else because of your previous relationship)
- Facilitating thought with emotion (e.g., thinking through what you will say to a friend, then perhaps changing plan when things aren't working well)
- Perceiving others' emotions (e.g., noticing your friend's slight frown and recognizing, perhaps, jealousy)
- Women tend to have higher EQ than men

- Another interesting finding on boosting Intelligence: The *Flynn effect*

- Average IQ has increased recently by 3 points every 10 years
- *g* has accounted for less of the variability as time progresses
- IQ tests are periodically re-normed
- Flynn effect may be increasing
- IQ increases, *g* accounts for less variability
- Strong effect on tests free of cultural bias

Raven's Progressive Matrices



Task: which of the numbered patterns best fits the missing cell?

Correct answer: **3**.

Educational Programs and Intelligence

- Head Start and similar projects
 - Most show only short-term IQ gains
 - Most gains evaporate over time
 - Thus, a disappointment. However...
- North Carolina's Abecedarian Project
 - Intellectual, medical, and nutritional enrichment
 - 5 years before kindergarten
 - Long-term 5-point IQ boost
 - Link: <http://www.fpg.unc.edu/~abc/>

Complications in Intelligence Testing: Stereotype threat

- Claude Steele and colleagues at Stanford University
 - Test a mixed group of people on a particularly ability
 - E.g., test a group of men and women on math skills
 - Typical finding: no significant difference
 - Test another mixed group but tell all test takers in advance that “women typically have been found to perform more poorly on this particular test.”
 - Result: women now perform more poorly.
 - The result does not occur, however: telling men they will perform more poorly does not lower their performance.
 - Thus, the information provided must fit the stereotype, must be plausible
 - Reason why stereotype threat occurs is not totally understood but may be attentional: you start thinking about the consequences of failure rather than simply doing well on the test
 - Cf. professional baseball pitchers throwing wildly (off by 20 degrees)
 - Cf. “icing down” the kicker in football

Implications in other arenas: small number of women going on for advanced degrees and jobs in mathematics and physics: Larry Summers affair at Harvard

Brain size and intelligence: Is bigger better?

- Humans do not have the largest brains in the animal kingdom!
- However, certain disorders shrink both brain size and IQ: people with Alzheimers, microencephalic patients (most are mentally retarded)
- Large brains do contain more neurons
- However, IQ seems to depend more on size of certain crucial brain areas (recall Einstein's wide parietal lobes, 15% greater than normal)
- Females tend to have smaller brains overall but they have equal IQs
- Correlation between brain size and intelligence is small
- Remember: Correlation is not causation! Brain activity may cause increase in brain size (c.f. muscles)

IQ and Mental Speed

- High IQs are correlated with speed of information processing
 - Smarter people take more time digesting problems
 - Smarter people are also more efficient at processing
 - Higher IQ people are even faster at judging which of two lines is longer

The brain, working memory, and intelligence: neuroimaging studies

- Parts of the lateral frontal lobes used in working memory are activated in tasks that require high g.
- Items on Raven's Progressive Matrices that require high visual-spatial reasoning ability activates parts of the frontal lobes used to hold information in working memory

Genes and intelligence

- There clearly is a link, as shown by twin studies (more below)
- There's much more to intelligence than just genes
- There is no single gene that controls intelligence; rather, a large set of genes.
- Heritability of IQ: the proportion of the variance in IQ that is accounted for by genes (as opposed to environment). Note: heritability was worked out in agriculture and in animal breeding long before it was applied to humans.

Heritability of human intelligence appears to be around .50, based on results from twin studies, including *identical twins raised apart*

- The correlations of IQs between adult MZ (identical) twins raised apart are higher than the correlations between DZ (fraternal) twins or non-twin siblings raised together
- Adopted children's IQs correlate higher with the biological mothers' IQ than the adopted mothers' IQ
- By adulthood, there is virtually no correlation between the IQs of adopted children and the biologically related children in a family..

Genetic Relatedness and IQ

