



Cognitive Psychology

Fall 2012

Intelligence, Problem-Solving, and Creativity

Some of this content is drawn from Chapter 10 of Feist & Rosenberg
“Psychology: Making Connections”

Van Selst

the capacity to learn from experience and adapt successfully to one's environment

Set of cognitive skills that includes abstract thinking, reasoning, problem solving, and the ability to acquire knowledge (Feist, p.374)

What is the purpose of the intelligence test?

Chinese civil service exams: measured aptitude

Galton: “natural selection” of intelligence as a heritable trait
(→ eugenics)

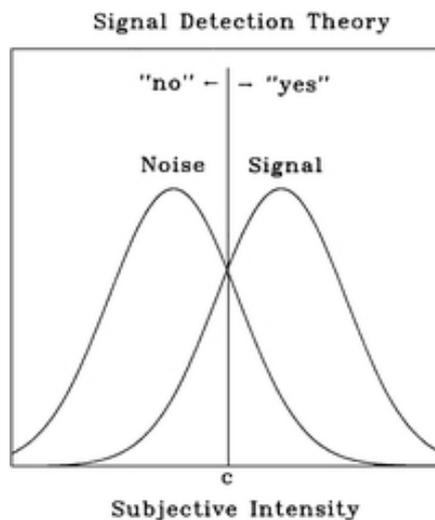
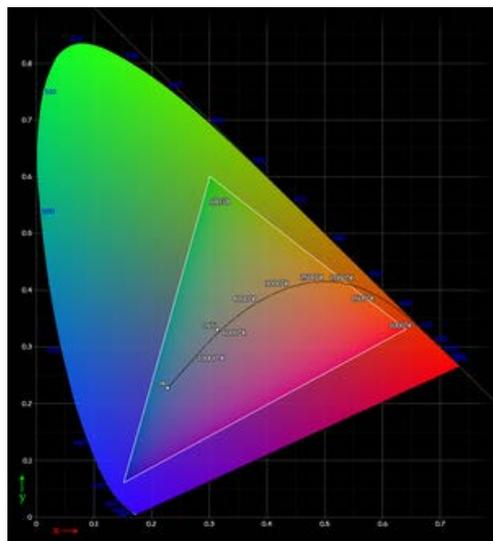
Stanford-Binet: measure educational level (identify slow learners)

Two Distinct Historical Approaches

Psychophysical/Physical Abilities (Galton)

Cognitive Aspects (Binet)

Francis Galton (1883) describes intelligence as a function of psychophysical ability and perceptual sensitivity (weight discrimination, pitch sensitivity, physical strength, etc). Psychophysical sensitivity is correlated with general intelligence (little “g”). Note, however that Galton’s crude measures failed to pick up (discriminate) bright, highly accomplished adults.



“Lumpers” versus “Splitters”

Spearman’s ‘g’ factor (**General Intelligence / little ‘g’**): the single common aspect that comes out as a shared element across many divergent measures of intelligence... originally conceived of as the central aspect or “mental energy” of intelligence (as opposed to the specific abilities uniquely measured by each individual test). A broad intellectual-ability factor used to explain why performances on different intelligence-test items are often correlated.

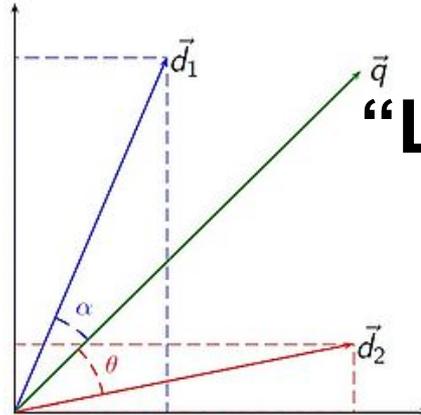
Support for little ‘g’ comes from **factor analysis**: a statistical technique used to identify clusters of test items that correlate with one another.

Spearman’s use of factor analysis supports the utility of IQ as a single score.



Thurston (following up on Spearman): saw intelligence as composed of seven primary abilities (derived via factor analysis)

- Verbal Comprehension
- Verbal Fluency
- Inductive Reasoning
- Spatial Visualization
- Number
- Memory
- Perceptual Speed



“Lumpers” versus “Splitters”

Guilford: extreme view of intelligence as composed of (up to) 150 abilities & factors... the most valuable contribution is that we do explicitly consider various kinds of mental problems, contents, and products in our views and assessments of intelligence.

Cattell: hierarchical model of intelligence. Cattell's model consists of two general subfactors for intelligence: **Fluid ability** (speed and accuracy of abstract reasoning of the type required for novel problems) and **crystallized ability** (accumulated knowledge and vocabulary). Vernon divides between practical-mechanical and verbal-educational.

COGNITIVE Approach to Intelligence

Gardner: “Frames of mind” *multiple intelligences*; another domain specific conceptualization of a variety of intelligences (rather than a Spearman’s monolithic ‘g’); controversial because it “demystifies” *intelligence* into the synonym “*ability*”

- Linguistic
- Logical mathematical
- Spatial
- Musical
- Bodily-kinesthetic
- Interpersonal
- Intrapersonal

Intelligence	Definition	Representative Professions
linguistic	Ability to learn, understand, and use both spoken and written language	Poets, writers, lawyers, politicians
logical-mathematical	Ability to analyze information and problems logically and to perform mathematical operations	Scientists, engineers, accountants
musical	Ability in performing, composing, or appreciating musical patterns	Musicians, dancers, song-writers
bodily-kinesthetic	Ability to use one's body or parts of it to solve problems or create products	Athletes, dancers, mechanics, craftspeople
spatial	Ability to think about and solve problems in three-dimensional space	Navigators, pilots, architects, sculptors
interpersonal	Ability to understand and be aware of other people's intentions, motivations, thoughts, and desires; also the ability to work well with and get along with others	Psychologists, social workers, teachers, politicians
intrapersonal	Ability to be aware of, understand, and regulate one's own behavior, thoughts, feelings, and motivations	Psychologists, monks, priests
naturalistic	Ability to recognize, classify, and understand the plants and animals in one's environment	Naturalists, biologists, botanists, veterinarians, hunters, farmers

“Lumpers” versus “Splitters”

Sternberg: Triarctic view of intelligence: three components (Analytic, Creative, Practical) intelligence aspects are used (typically conjointly) for problem solving, etc.

- **Analytic:** mental steps or components used to solve problems
- **Creative:** use of experience in ways that foster insight (creativity / divergent thinking)
- **Practical:** ability to read and adapt to the contexts of everyday life

COGNITIVE Approach to Intelligence

Alfred Binet (Binet & Simon, 1916) was interested in three aspects of intelligence: Direction, Adaptation, and Criticism. The original interest was in the assessment of ‘mental age’ -- the average level of intelligence for a person of a given age.

Note that the intent of Binet’s (1905) work was to predict which children would benefit from which types of educational approach (i.e., which children would have trouble in a normal classroom). Interestingly (in comparison to the head start program), the idea was that intelligence was stable and that educational opportunity could be tailored to intelligence (head start’s stated goal is to increase intelligence).

Terman’s (1916) work on the Stanford-Binet led to the concept of “IQ” (following on the work of Stern).

- **Mental age:** in an intelligence test, the average age of the child who achieve a certain level of performance
- **Stanford-Binet:** an American version of Binet's intelligence test, mean IQ set to 100.
- **Intelligence Quotient (IQ):** originally defined as the ration of mental age to chronological age; now represents a persons performance relative to same-age peers.

Lewis Terman (Terman & Merrill, 1937)'s ***Stanford-Binet Intelligence test*** and David Weschler's ***Weschler Adult Intelligence Scales*** (WAIS-III) [and WISC-III] are widely used today.

*The Weschler Scales produce three values: **verbal** subtest, **performance** subtest, and an **overall** score.*

Modern Intelligence Tests (WAIS)

The verbal score depends on:

- Comprehension (social knowledge/sayings: why do people buy automobile insurance?)
- Vocabulary (definitions of words: what does 'procrastinate' mean?)
- Information similarities (how are two concepts similar? Boats & trains?)
- Arithmetic (simple numeric problems such as amount of change: if eggs cost 96 cents per dozen, how much does an egg cost?)
- Digit span (listen carefully & repeat the sequence when I am through: 4 8 7 5 2)

The performance score is based on:

- **Object assembly**
 - (using block shapes to make a picture [puzzle])
- **Block design**
 - (producing a pattern match using component blocks)
- **Picture completion**
 - (what is missing from this picture? [steering wheel])
- **Picture arrangement**
 - (tell a story in chronological order)
- **Digit symbol**
 - (symbol-digit transcription: transcribe appropriate symbol into each space)

Weschler, like Binet, had a conception of intelligence beyond test scores and school performance.

GROUP APTITUDE TESTS

underlying assumption of SAT, GRE, GMAT, LSAT, etc. is that they measure aptitude (potential) for academic learning

SAT: designed to measure ‘bias free’ ability to perform well academically; designed to level the playing field for bright students from modest backgrounds. (and Kaplan’s contribution to training testing; likely ‘real’ effect is 30 to 50 points on the 400-1600 point scale) – trainees are likely to be the more well-off, better-prepared, more practiced (or repeat) test-takers

How well does it measure what it is supposed to measure?

Standardization: procedure by which existing norms are used to interpret an individual's test score.

Reliability: consistency; the extent to which a test yields consistent results across time, across alternate forms, or across items within the scale.

- **Test-retest reliability:** consistency of results across test-taking episodes of the same test
- **Split-half reliability:** consistency within the scale
- **Alternate forms reliability:** consistency across alternate forms of a test

Validity: the extent to which a test measures what it is designed to measure

- **Construct validity:** does it measure the entirety of the concept that it is supposed to measure?
- **Criterion validity (predictive validity):** predicting a simultaneous or future event (e.g., SAT + high-school grades do a good job of predicting college gpa; much less so for non-academic endeavors).
- **Face Validity:** does it “look” like it measures what it is supposed to measure?



Are IQ tests biased?

- **Cultural test bias hypothesis**
 - Are Group differences in IQ scores caused by different cultural and educational backgrounds, as opposed to real differences in intelligence?
- **Test bias**
 - Characteristics that produce different outcomes for different groups
- **Test fairness**
 - How are the test scores to be used? What is the consequence (typically for the group)?

NOTE: An overview (some awareness of cultural test bias and test fairness) will suffice

Galton → heredity component → Eugenics

Goddard → “immigrants are far less intelligent” → restricted immigration

Jensen → African Americans 15 points below Caucasian (now 10-13) → ?

Culture-fair questions (avoid “what does C.O.D. mean”); still a difference

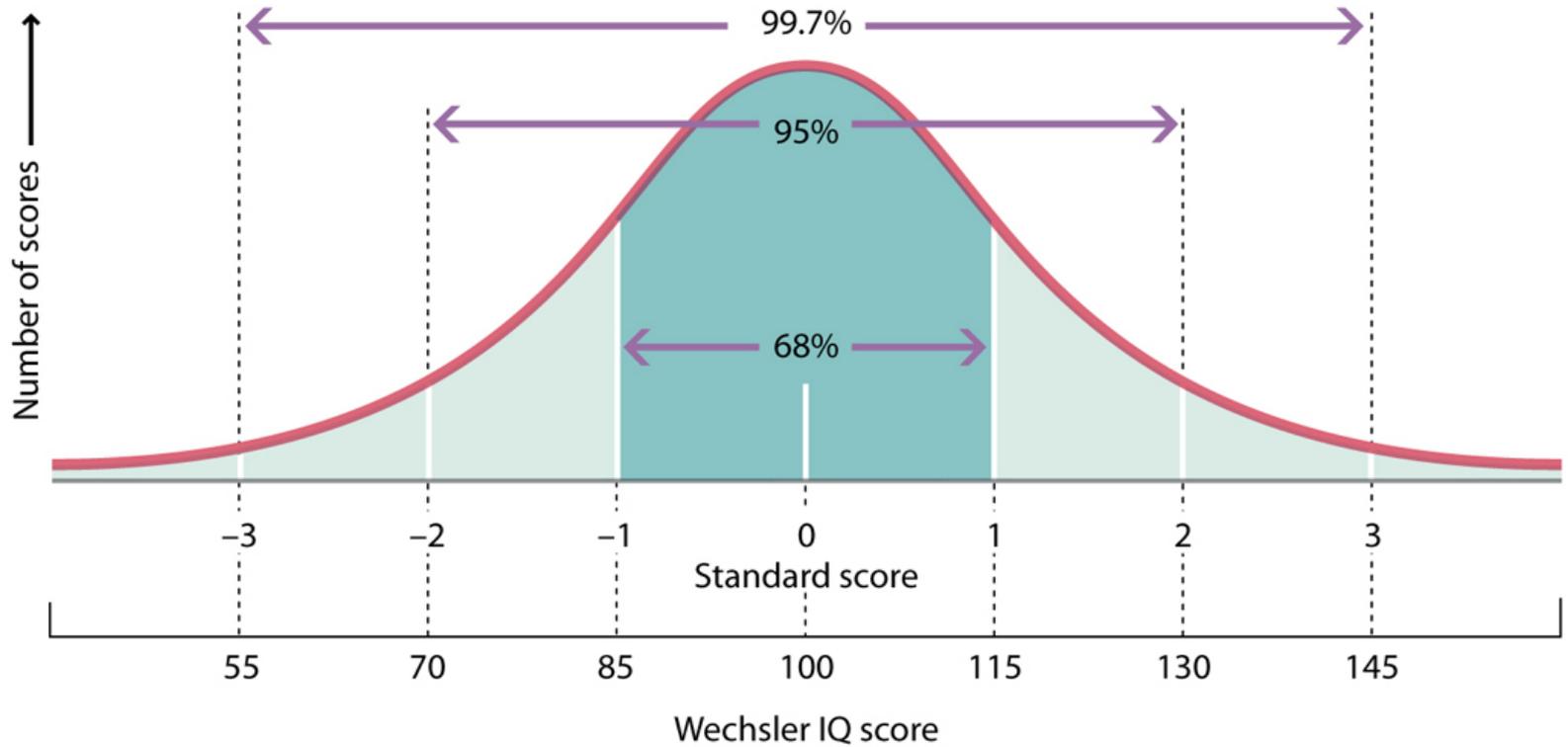
Statistically valid for purposes of prediction

Court challenges w.r.t. bias (50/50)

“Labeling” effect / Stereotype influences

Shockley → “voluntary sterilization” for low IQ individuals

Extremes of Intelligence



Mental retardation

- Significant limitations in intellectual functioning
- I.Q. of 70 or below
- Adaptive behavior
- Down syndrome

Giftedness

- High end of the intelligence spectrum
- IQ of 130-140 or above
 - Prodigy
 - Savant syndrome

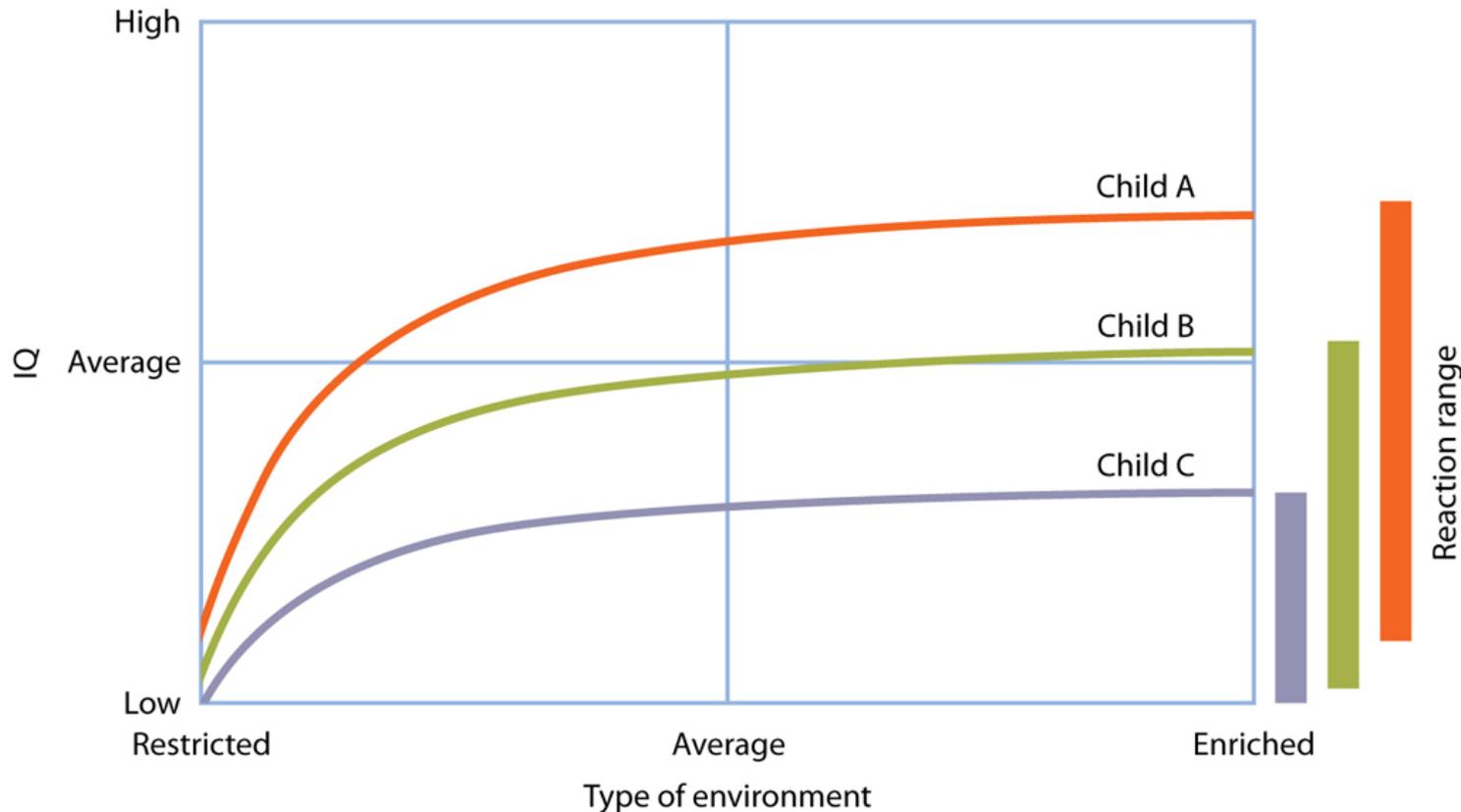
Twin-adoption and family studies demonstrate the interconnectedness

Reaction range

- Genetically determined range of responses by an individual to his or her environment

Reaction Range and Intelligence

Reaction Range: suggests heredity puts an upper and lower bound on an individual's potential; but environment determines where the individual actually ends up.



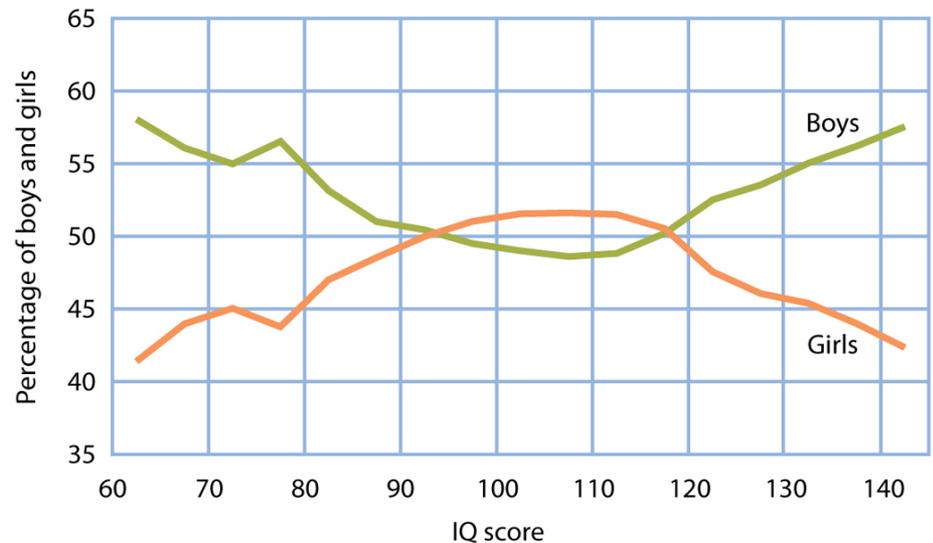
Group Differences in Intelligence Scores

Race-ethnicity

- Groups vary on IQ scores
- Are tests biased?

Gender

- More variability among men than among women



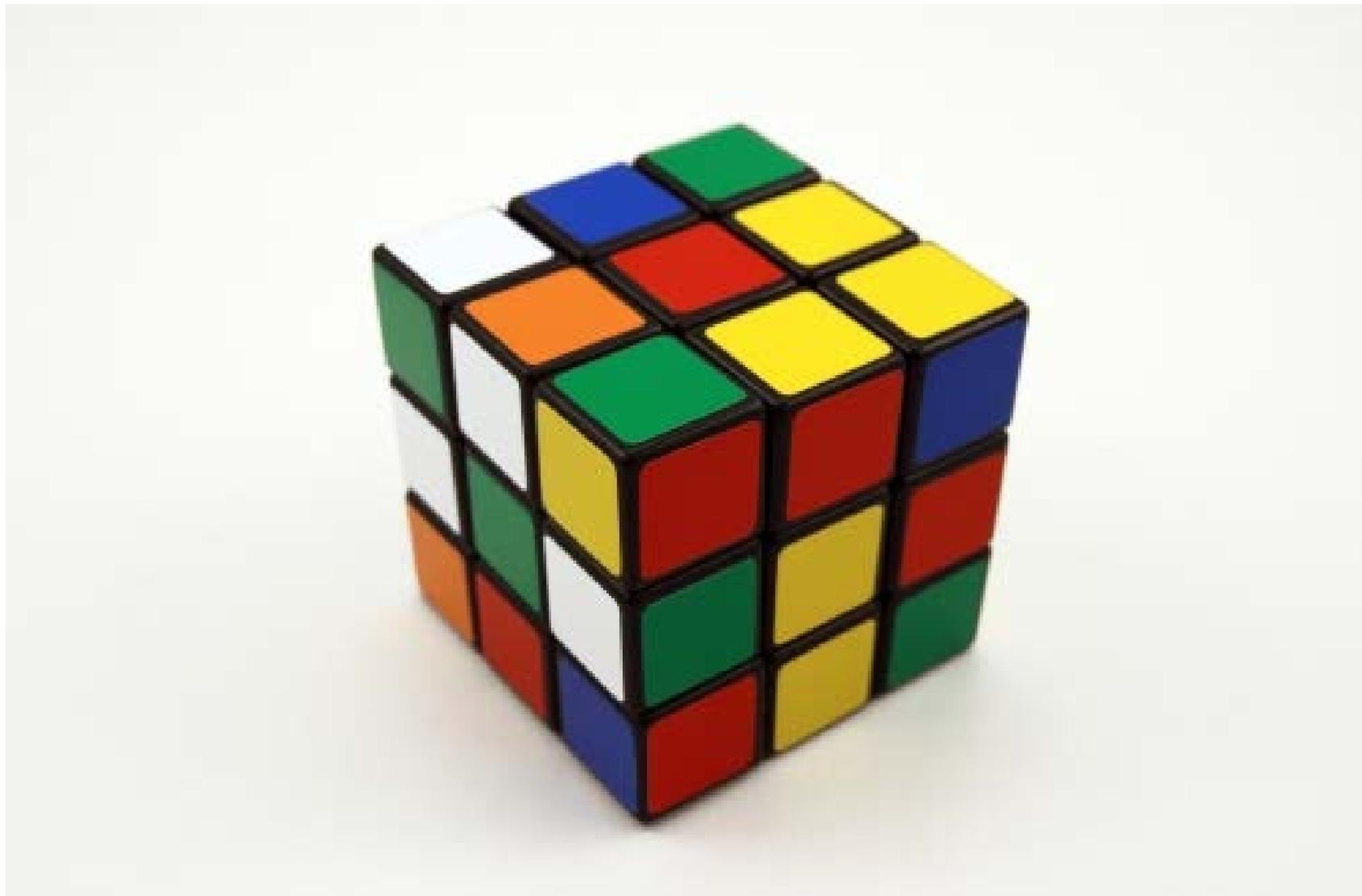
African cultures value social skills such as being socially responsible and active in family life

Asian cultures emphasize humility, awareness, and doing the right thing

What is the likely impact on intelligence testing?

WARNING NOTE ON INTELLIGENCE TESTS: very susceptible to 'testing effects'.. How you ask the questions can determine the answers you receive (e.g., U.S. Immigration testing that found more foreigners to be 'sub-intellectual'... largely due to the use of biased testing procedures).

Heritability: the allocated role of nature versus nurture depends on the range of genetic variation or the environments that the individuals developed in. The summary is that heritability indexes do not generally accurately represent what they purport to.



Problem (Definition) & Problem Solving

A problem is defined as the difference between the current state and a goal state.

Characteristics of problems:

- Goal directedness
- Sequence of steps
- Cognitive operations
- Subgoal decomposition

Convergent thinking problems

- Have known solutions
- Require analytical thinking

Divergent thinking problems

- Have no known solutions
- Require novel solutions



PROBLEM SOLVING APPROACHES

- **Algorithms:** precise set of rules guaranteed to produce the correct answer
- **Heuristics:** rule of thumb, and informal strategy or approach that works under some circumstances (not all)
- **Trial and error:** try solutions until you find one that works
- **Insight** - deep useful understanding of the nature of the problem; a form of problem solving in which the correct solution seems to pop into mind all of a sudden (e.g., the related “incubation effect”); sudden solutions that come to mind in a flash
- **Analogy** - relationship between two similar problems or concepts, bringing the two concepts into some kind of alignment or relationship that highlights their similarities and differences.
- The text describes “**thinking outside the box,**” which requires breaking free of self-imposed conceptual constraints and thinking about a problem differently

Difficulties in Problem Solving :

- Fixation
 - Negative Set (Luchin's Water Jug Problem)
 - Inability to break out of a particular mind set and form a fresh perspective
 - Functional Fixedness (Duncker's Candle Problem)
 - Blind to unusual uses of common objects or procedures
- Failures of problem representation (nine-dot problem)
- Confirmation Bias (Wason's 2-4-6 sequence... what's the rule?)

The text describes “Mental Set”

- Tendency to continue to use problem-solving strategies that have worked in the past

TABLE 8.3: LUCHIN'S 1942 WATER JUG PROBLEMS

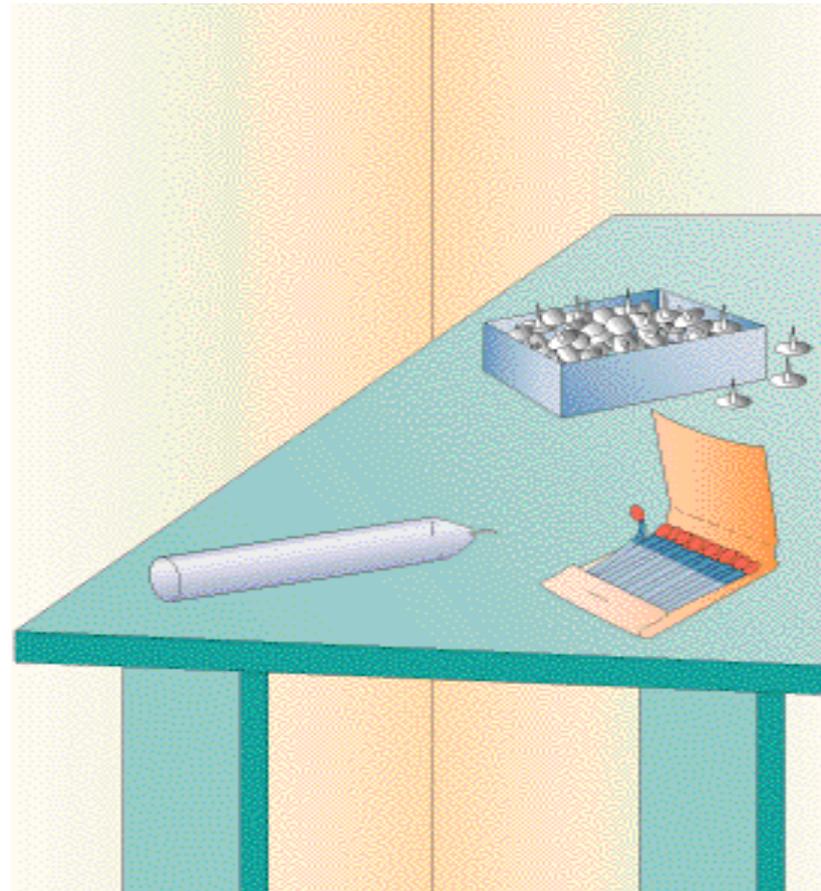
Problems	Capacity of Jug A	Capacity of Jug B	Capacity of Jug C	Desired Quantity
1	21	127	3	100
2	14	163	25	99
3	18	43	10	5
4	9	42	6	21
5	20	59	4	31
6	23	49	3	20
7	15	39	3	18
8	28	76	3	25
9	18	48	4	22
10	14	36	8	6

Note: All volumes are in cups.

Duncker's Candle Problem

Difficulties in Generating Solutions (Functional Fixedness)

Using only the objects shown in the picture, mount the candle to the wall.



The Nine-Dot Problem



- Connect all 9 dots.
- Use only 4 lines.
- Do not lift your pencil from the page after you begin drawing.

Confirmation bias: our tendency to seek evidence that confirms (rather than disconfirms) our decisions and beliefs [this is why so many people have trouble with hypothesis testing and why so many people fail Wason's three-number sequence 'rule-finding' challenge:

- 2-4-6 ... test any set of three numbers to check your hypothesized rule. When you think you know the rule, speak it aloud.

Creativity is thinking and/or behavior that is both novel/original and useful/adaptive

Stages of Creative Problem-Solving

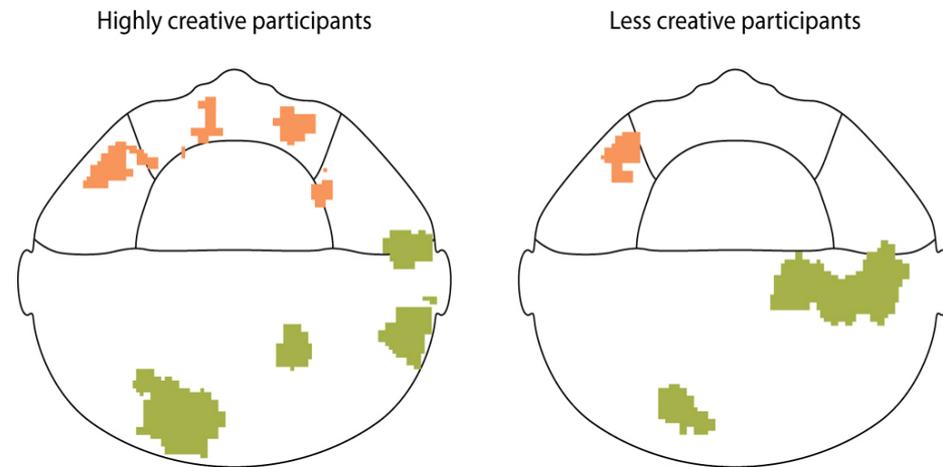
- Preparation
- Incubation
- Insight
- Elaboration-verification



Genius is closely related to creativity in that it combines high intelligence with achievements that change entire fields such as art, technology, music, science, and business

Creative insight and the Brain

- Insights occur more in the right hemisphere than in the left hemisphere
- Creative people solving creative problems show more balanced activity between their right and left frontal lobes than less than creative people



What is CREATIVITY? THREE PERSPECTIVES

Torrence (1974, 1984, 1988) test of creative thinking: It is **how much you produce**. It includes the diversity, numerosity, and appropriateness of responses to open-ended questions (such as think of all the possible ways to use a paperclip). There is a particular emphasis on how much a person had used unusual or richly textured details in completing a figure or task.

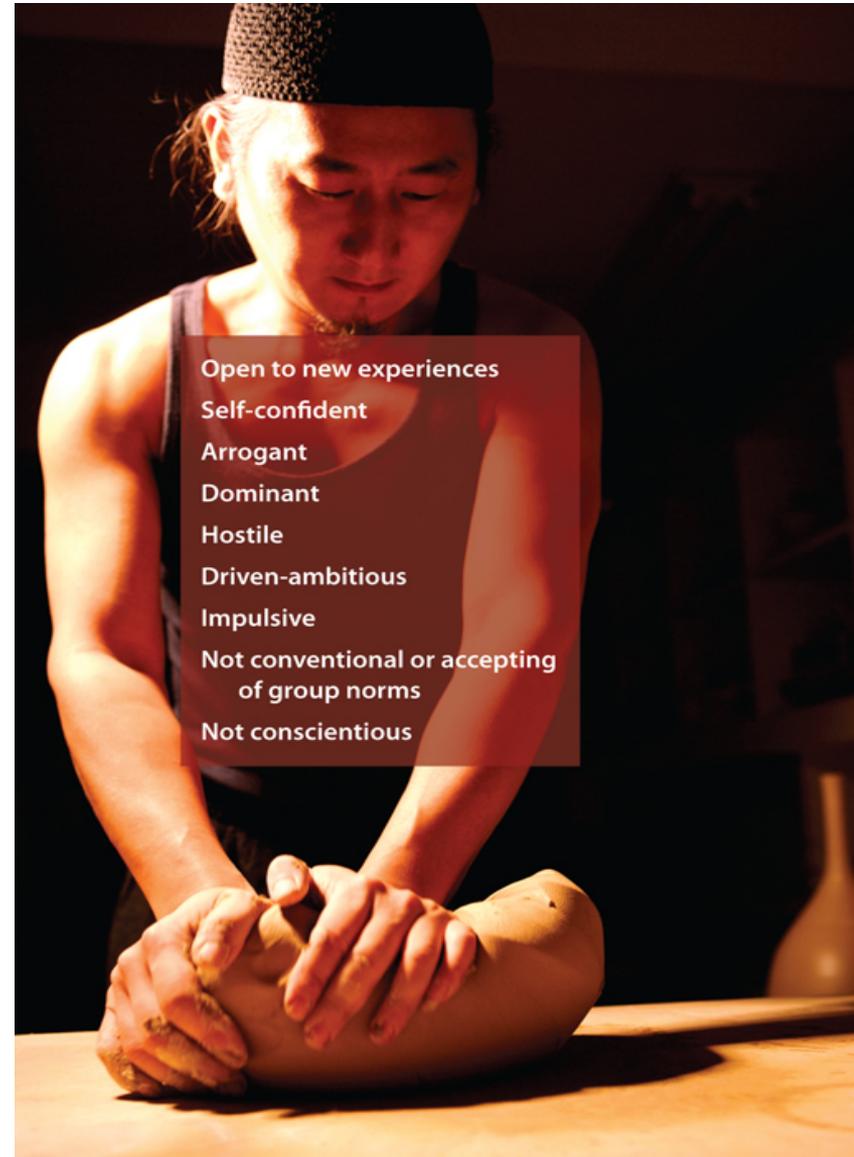
- **Ideational fluency**
 - Ability to produce many ideas
- **Flexibility of thought**
 - Ability to come up with many different categories of ideas and think of other responses besides the obvious

Wiesberg (1988, 1995, 1999): what distinguishes remarkably creative individuals from less creative individuals is their **expertise and commitment** to their creative endeavor.

- Highly creative individuals work long and hard, studying the work of their predecessors and their contemporaries, to become thoroughly expert in their fields. From this it could be argued that creativity itself is just the application of expertise (i.e., nothing special).

Baron (1988): **personality-based** perspective. An openness to new ways of seeing, intuition, alertness to opportunity, a liking for complexity as a challenge to find simplicity, independence of judgment that questions assumptions, willingness to take risks, unconventionality of thought that allows odd connections to be made, keen attention and a drive to find pattern and meaning. These attributes, when coupled with the motivation and the courage to create produce a creative individual.

Personality traits
shared by creative
artists and scientists





- Extremely high in motivation
- Nonconforming but dedicated to maintaining standards of excellence and self-discipline
- Deep belief in the value of their creative work (and will criticize & improve)
- Careful choice of problem
- Thought process characterized by insight and divergent thinking
- Risk taking
- Extensive knowledge of relevant domain (experts have: more knowledge, better knowledge, and more inter-connected knowledge structures)
- Profound commitment to the creative endeavor

TYPES OF CREATIVE CONTRIBUTIONS

NOTE: I WILL NOT ASK YOU TO KNOW THESE “TYPES”

- **replication:** to show that a given field is where it should be
- **redefinition:** refine where the field is
- **forward incrimination:** move the field in a direction it is already moving
- **advance forward incrimination:** moves beyond where others in the field are ready for the field to go
- **redirection**
- **reconstruction-redirection:** attempt to move the field back so that it can move forward from that point
- **reinitiation:** a new and not yet reached starting point
- **integration:** synthesis of formerly distinct or divergent ideas

NOTE: I WILL NOT ASK YOU TO KNOW THESE “TYPES”



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