

PS416
Personality & Individual Differences

Intelligence B
The Structure
of Intelligence

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Plan for my Three Topics

- 1) Topic A: Tools and Methods for Intelligence Testing
 - Reliability, Validity, Standard Error of Measurement
 - Intelligence test formats and items
- 2) Topic B: The Structure of Intelligence
 - Conceptualisations of intelligence
 - Single Factor, Hierarchical, Multiple Ability and Contextual theories
- 3) Topic C: Uses of Intelligence, Critiques of Intelligence
 - Criticisms of the construct of intelligence
 - Using intelligence tests to predict people's futures
 - Criticisms of the validity of intelligence tests

The Structure of Intelligence

- What is intelligence?
 - Three categories of conceptualisation
- Clarifications
- The structure of intelligence
 - Single factor theory
 - Hierarchical theories
 - Multiple ability theories
 - Contextual theories
 - Summary and evaluation
- Choosing an intelligence test

What is Intelligence?

- Something to do with successful reasoning/problem solving?
- Sternberg (1990): very many definitions ranging from the narrow to broad
 - *Intelligence is what the tests test*
E.G. Boring (1923)
 - Sounds trivial, but the methodology this implies turned out to be extremely powerful (Carpenter, Just, & Shell, 1990)
 - *Intelligence is the capacity of a person to understand the world and meet its demands*
Weschler (1975)
 - Sounds impressive, but by itself, and without strict definitions of key words, this is utterly meaningless

What is Intelligence?

- Howard (1993)
 - Rather than wade through endless definitions, look at the underlying properties of each one and categorise it
 - Intelligence =
 - 1) Something in the head
 - 2) A particular way in which people behave
 - 3) The sum total of all abilities and skills

What is Intelligence?

- *Intelligence = something in the head*
 - A *property* of the brain that is related to test score
 - Jensen: neural transmission speed
 - H.J. Eysenck: information transmission accuracy
 - Assumes that there is one single key package of brain differences related to one single test score
 - Implies research into the cognitive neuropsychology of intelligence (e.g., Chabris, 2007; Duncan, 2010)
 - Easy to measure people, and rank order them

What is Intelligence?

- *Intelligence = a particular way in which people behave*
 - Some people more likely to behave in this way than others
 - Anastasi: **not** an entity within the organism but a quality of behaviour
 - Carpenter *et al.*: the ability to deal with novelty and adapt thinking to a new cognitive problem
 - Assumes that differences in test scores reflect an identifiable difference in behaviour between people
 - Implies, e.g., *reductionist* research into underlying cognitive psychology of intelligence (e.g., Carpenter, Just, & Shell, 1990; Stanovich & West, 1998)
 - (Fairly) easy to measure people, and rank order them

What is Intelligence?

- *Intelligence = the sum total of all abilities and learning*
 - People have *different* strengths and weaknesses, both in terms of ability and contextualised skills
 - Anderson: people differ in range of skills and skill quality
 - Holyoak, Richardson: success depends on possession of appropriate schemas, which anyone can acquire
 - Assumes differences in test score merely reflect differences in puzzle experience
 - Implies, e.g., *holistic* research into the cognitive psychology of schema and skill acquisition (e.g., Ericsson & Charness, 1994; Richardson, 1991)
 - Impossible to measure and rank order people, should not even be trying to measure them

What is Intelligence?

- So, what is intelligence then?
 - No category of theory is intrinsically more correct than the rest
 - All are investigating legitimate aspects of intelligent behaviour
 - Many different reasons why some people might perform better than others at different tasks
 - Differences are in emphasis and research agenda
 - The **reader** needs to understand any differences in assumptions and their consequences for theorising
 - Look out for *false dichotomy* fallacies
 - Look out for *straw man* fallacies

Clarifications

- General intelligence versus *IQ* versus ***g***
 - General intelligence = *absolute level* of cognitive ability
 - *IQ* = *age standardised* performance,
i.e., compared with everyone else of similar age range
 - Typically, raw scores scaled to have Mean = 100, *SD* = 15
 - Enables people to be compared irrespective of test used
 - ***g*** = technical term to label underlying cause of individual differences in intelligent behaviour (and *IQ*)
- Terms are reasonably interchangeable in most contexts

Clarifications

- Does research into the structure of intelligence assume that differences are owing to *nature* (rather than *nurture*)
 - No, the only assumptions are that general intelligence might exist and might be measurable
 - Completely neutral as to how individuals reached their current status(es)

The Structure of Intelligence

- How many categories of ability account for current performance and predict future outcomes?
 - Are people good at maths likely to be good at English too?
- Ideally, aim for *parsimony*, the smallest number needed to account for the data
 - High numbers of abilities might potentially be more predictive but
 - Harder to replicate structure
 - Require more tests
 - May not justify additional predictive power

The Structure of Intelligence

- Four *categories* of theory
 - 1) Single factor theory
 - 2) Hierarchical theories
 - 3) Multiple ability theories
 - 4) Contextual theories

Single Factor Theory

- Developed by Spearman (1900s to 1930s)
 - Observed that correlations between school subjects were always non-zero, always positive
 - Performance at mental tasks always correlated
 - Underlying cause = ***g***, general intellectual ability
- Correlations never perfect, not always even high
- Performance at any given task = ***g + s***

Single Factor Theory

- What is *g*?
 - Spearman: mental energy/power
 - Raven: ability to detect order out of chaos (inductive reasoning?)
 - Carpenter *et al.*: Working memory capacity; ability to create and control long nested sequences of actions
 - *Might* have a neuropsychological basis

Single Factor Theory

- What are s ?
 - *Specifics*: knowledge/skill related to a particular task
 - Contextualised: unique bundle for that particular task
 - No point trying to measure them, absolutely task specific, useless for any general predictions

Single Factor Theory

- Spearman's single factor theory:
 - Only *one intellectual* variable, ***g***, worth testing in order to account for performance and make predictions
 - Common misconception: ***g*** is absolutely deterministic, summarises all our potential and controls our future
 - NO! ***g*** only mops up the ***predictable*** intellectual variance
 - Endless potential for people to go beyond what ***g*** can predict, this is what the ***s*** components encompass
 - Spearman: beyond ***g*** we cannot make predictions about intellectual destiny
- Very influential theory
- Has stood the test of time and is difficult to improve upon

Hierarchical Theories

- Developed from the 1940s onwards as new statistical techniques, then computers, were created
- ***g*** is accepted as an important universal predictor
- But there also exist mid-level *specific abilities* that predict performance at relevant tasks
- Specific abilities **NOT** the same as Spearman ***s*** components
- Performance = ***g*** + ***specific ability*** + ***s***

Hierarchical Theories

- Frequent specific abilities:

- Verbal ability

???	Tree
Egg	Chicken

- a) Coop b) Nest c) Chick
d) Seed e) Sapling

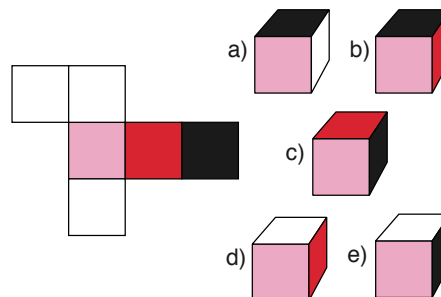
- Numerical ability

Which numbers are next?

2, 3, 4, 6, 6, 9, ???, ???

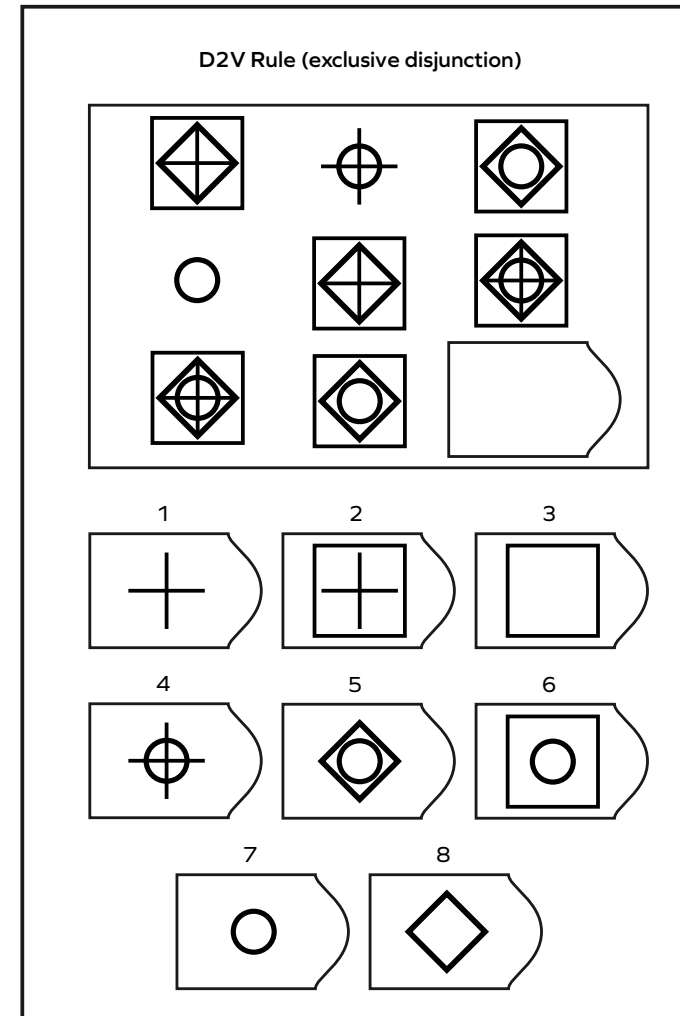
- a) 8, 10 b) 12, 16 c) 8, 12
d) 12, 12 e) 8, 16

- Spatial ability



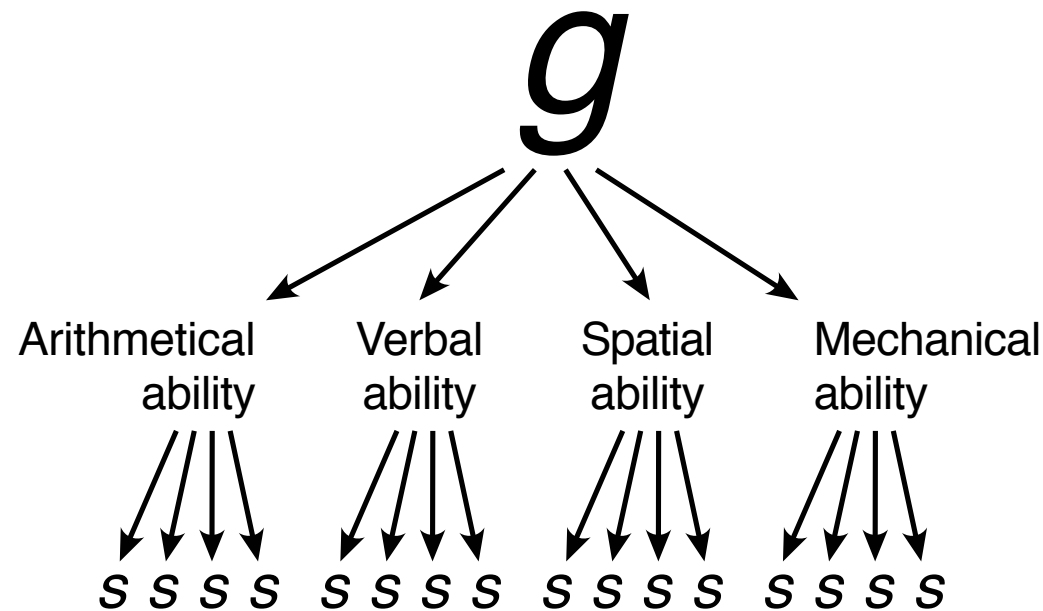
Hierarchical Theories

- NB. Ravens Matrices are measuring general reasoning ability **NOT** uniquely spatial ability
- Logic is being identified from shapes, the shapes themselves are not being transformed
- Surface appearance of items need not be related to what they are measuring



Hierarchical Theories

- Burt (1940s) proposed the first hierarchical theory
- Emphasised *specific abilities* but these were correlated
- ***g*** = sum total of specific abilities, at the *top* of hierarchy



Hierarchical Theories

- Horn & Cattell (1970s) proposed the most elaborate hierarchical theory
 - Identified 27 primary abilities
 - These were not independent, five higher-order top-level abilities identified to account for inter-correlations

Examples of Horn-Cattell Primary Abilities

	Deductive Reasoning	
	Inductive Reasoning	
Verbal Ability	Word Fluency	Perceptual Speed
Numerical Ability	Spelling Ability	Perceptual Accuracy
Spatial Ability	Memory Span	Motor Speed
Mechanical Ability	Associative Memory	Motor Coordination
	Rote Memory	
Musical Pitch Sensitivity		Representational Drawing Ability
Musical Rhythm/Timing		Creativity/Originality
		Aesthetic Judgment

Hierarchical Theories

- Horn–Cattell higher order abilities
 - g_f fluid intelligence (see below)
 - g_c crystallised intelligence (see below)
 - g_v visualisation ability, cf spatial ability elsewhere
 - g_r retrieval fluency: ease of accessing information from long term memory
 - g_s cognitive speed

Hierarchical Theories

- g_r/g_s = efficiency of basic cognitive operations
 - Will influence performance for individual tasks where speed/rapid information retrieval important
 - Unlikely to affect long-term intellectual achievements?
- g_v = ability to imagine manipulations of objects and space
 - The most frequently identified specific ability, relationship to core intelligence remains uncertain
 - A component of core intelligence, or independent?
 - Burt: a component
 - Horn-Cattell: independent

Hierarchical Theories

- g_f/g_c = two types of intelligence at the top of hierarchy
 - *Fluid intelligence* = domain-free reasoning ability
 - Important for novel tasks and also complex tasks where a solution cannot be retrieved from memory
 - Closely linked to plain g in other theories
 - *Crystallised* = domain-specific skills and knowledge
 - Represents the extent to which skills and knowledge important to context and culture have been acquired
 - Tests of crystallised intelligence will have cultural bias by definition
 - Culturally biased tests measure crystallised intelligence?

Hierarchical Theories

- Some researchers such as Kline (1991) favour fluid-crystallised distinction
- Others such as Brody (1992) less sure
 - g_f (ability) determines acquisition of g_c (achievement)
 - In practice, the two will be too correlated to distinguish
- Benefit of Horn-Cattell theory: encouraged researchers to be explicit about nature of g and how best to measure it

Hierarchical Theories

- Overall: hierarchical theories
 - Theoretically appealing, especially for researchers who believe in complex multifaceted human potential
 - Practically problematic
 - A good test of **g** accounts for much of predictable variance at intellectual tasks
 - Difficult to show that added complexity of a hierarchical theory pays back in terms of increased predictive power

Multiple Ability Theories

- Single factor and hierarchical theories both always include a *general* intelligence factor
 - For every intellectual task there exists at least one factor that predicts at least some performance
- Multiple ability theories: people have separate *independent, uncorrelated* specific abilities
 - For any intellectual task, performance will depend on a persons skill level at appropriate combinations of these
 - But there exists no general intelligence factor that predicts at least some performance at every task

Multiple Ability Theories

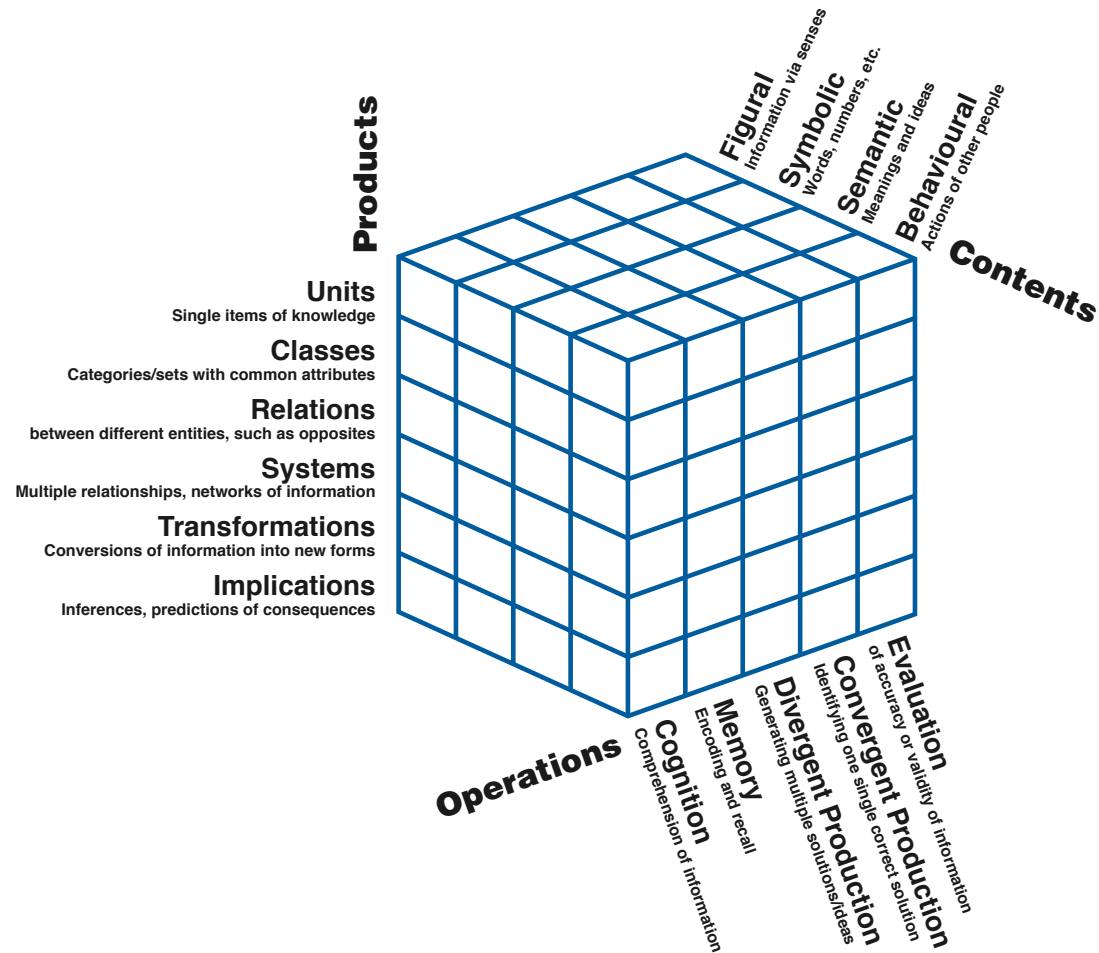
- Thurstone (1930s)
 - Claimed to have identified seven independent primary mental abilities
 - Verbal comprehension Numerical ability
 - Perceptual speed Spatial visualisation
 - Verbal fluency General reasoning
 - Memory
 - No general intelligence factor
 - However, the statistical analysis (*factor analysis*) had been performed to force uncorrelated abilities
 - When this criterion was relaxed, the abilities became correlated, and a general **g** factor could be identified

Multiple Ability Theories

- Guilford (1960s) *Structure of Intellect*
 - In his own research, 20% of correlations between cognitive tasks found to be non-significant
 - Therefore, there cannot be a universal predictor (no ***g***)
 - Guilford identified:
 - Four contents (types of material people think about)
 - Five operations (the thinking methods people use)
 - Six products (the outcomes of thinking)
 - All independent of each other
 - Gives the *Structure of Intellect* cube

Multiple Ability Theories

- Guilford's *Structure of Intellect* cube



Multiple Ability Theories

- Theory never gained widespread support
 - Supposedly, every combination is measurable with a different unique test, 120 of them
 - In practice, not all combinations seem coherent
 - Acceptability hindered by weak grounding in language of either cognitive psychology, or intelligence testing
 - Researched army officer trainees, restricted range explains lack of general factor
 - Basketball example, do people vary in height?

Multiple Ability Theories

- Gardner (1990s) *Multiple Intelligences*
 - Claims that hierarchical theories of intelligence, and their **g**-focus reflect bias by past researchers
 - They have clear ideas as to how intelligence is structured
 - Measure performance at tasks that they believe important
 - Can only find abilities relevant to their own choice of tasks

Multiple Ability Theories

- Gardner: there are key domains of ability that are independent, they effectively function in isolation
 - *Savant syndrome*: people with moderate to severe mental disability sometimes excel at **one** single task
 - *Brain damage*: can selectively impair **one** single skill, all others apparently left intact
 - *Gifted people*: excel at **one** particular domain, all other domains are performed as per typical people

Multiple Ability Theories

- Patterns of excellence and loss imply eight separate independent intelligences
 - Logical-mathematical: *Scientist?*
Linguistic: *Novelist?*
Spatial: *Navigator?*
Musical: *Composer?*
Inter-personal: *Counsellor?*
Intra-personal: ??? [*Awareness of self, needs, wants*]
Bodily-kinesthetic: *Dancer?*
Naturalistic: *Farmer?*

Multiple Ability Theories

- Popular approach, but many criticisms
 - Qualitative analysis not followed up by testing, measurement, statistical analysis to support proposal
 - How much can performance of unique/special/rare individuals be generalised to everyone else?
 - Much more complicated picture for each specialist population
 - *Brain damage*: rarely clear-cut, the most-clear-cut cases of permanent isolated loss are very much the minority
 - *Gifted people*: multiple domains of skill are actually quite common, historical analyses need care (Simonton, 2007)
 - *Savant syndrome*: the extent and quality of savant skills are related to the intelligence of the savant (Miller, 1999)

Multiple Ability Theories

- Popular approach, but many criticisms
 - False accusations of bias and task omission, e.g., Horn-Cattell primary abilities, see Slide 22
 - Theory is not so radical
 - Logical-mathematical intelligence looks like ***g***
 - Therefore it is crucial to confirm the independence of the factors
- Nonetheless, emphasis on going beyond traditional domains of ability is still useful

Contextual Theories

- Ceci, Ericsson, Holyoak, Howe, Richardson, Simon, (1980s to 2000s)
 - Skill depends on experience, acquired for specific tasks in specific contexts, skills do not generalise
 - Everyone behaves intelligently in their own context
 - Nobody behaves intelligently outside of own context
 - Performance is predicted by possession (or not) of relevant domain-specific knowledge and skill

Contextual Theories

- Ceci, Ericsson, Holyoak, Howe, Richardson, Simon, (1980s to 2000s)
 - Learning of skill is predicted by time and motivation
 - Anyone can learn, there is no general ability
 - Test scores provide no worthwhile measure of what people can do, and are actually misleading
 - Apparent predictive power of test scores is due to confounds, such as test experience and motivation
- Not a theory of the structure of intelligence, instead a theory of why intelligent behaviour can have no structure

Summary and Evaluation

- Each category of theory can be summarised in a sentence
 - Single factor theory
 - *One thing predicts everything*
 - Hierarchical theories
 - *Something predicts everything*
 - Multiple ability theories
 - *Nothing predicts everything*
 - Contextual theories
 - *Nothing predicts anything*

Summary and Evaluation

- Their success likewise
 - Single factor theory
 - *Crude but very effective*
 - Hierarchical theories
 - *Hard to identify their additional utility*
 - Multiple ability theories
 - *Very hard to dismiss **g***
 - Contextual theories
 - *Extreme view is untenable*

Summary and Evaluation

- Almost impossible to identify the best theory on the basis of research and data
- Sternberg (1990) *Metaphors of Mind*
 - Different theories of the structure of intelligence are like maps: different emphasis and levels of detail
- Choose the map that meets your own research needs

Choosing an Intelligence Test

- Psychometric tests were developed before theories of intelligence
- Tests and theory do not always mesh together comfortably
 - Highly verbal tests, with many general knowledge questions, measure cultural skills at the expense of ***g***?
 - Tests may have subscales that don't map onto the specific abilities identified by hierarchical theories
 - *Performance IQ versus Verbal IQ*
 - *Verbal versus Non-verbal IQ*
 - Even if subscales are appropriate, validity data needed to show that these are not merely re-measuring ***g***

Choosing an Intelligence Test

- How to measure ***g***
 - Raven's Progressive Matrices
 - Correlated with ***g*** (or ***g_f***): $r = .7$ to $.8$
 - Measure virtually nothing else (Kline 1993)
 - Internationally recognised/standardised benchmark

Choosing an Intelligence Test

- All other tests
 - Read the manual
 - Do the test yourself
- Test companies are not charities, they exist to make a profit
 - Be sceptical of claims
 - Read Blinkhorn & Johnson (1990)
 - Look for validity data
 - Choose carefully

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