Problem Solving and Intelligence
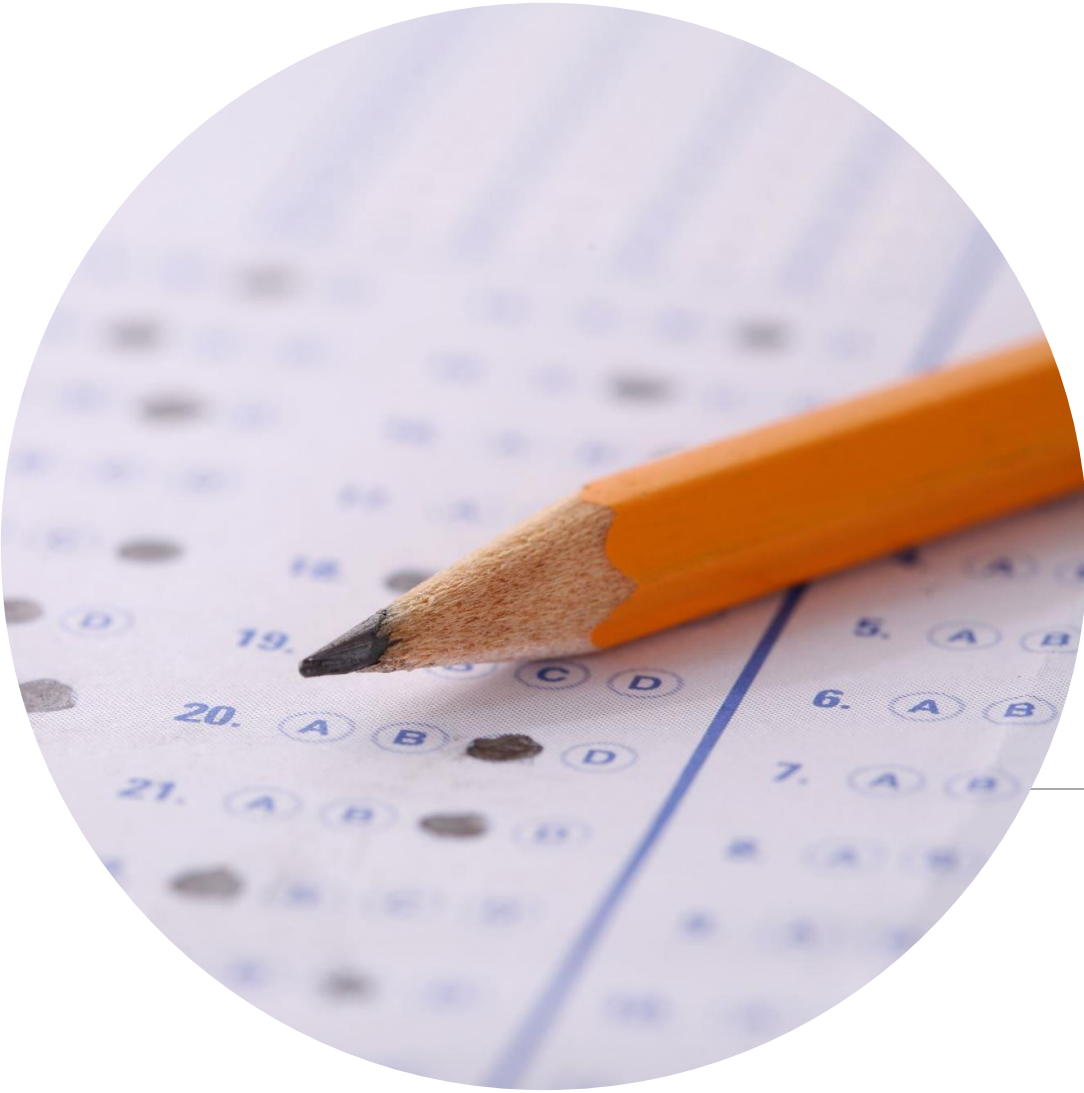
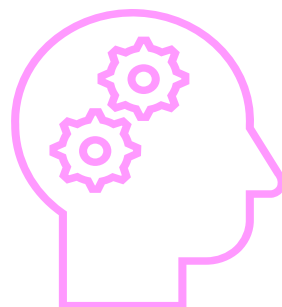Gifted

Bright/quick

Memory /recall

Thoughtful

Talented

Innovative

Creative

Street Smart

Gen.Knowledge

OMG

Connect the dots

STEM
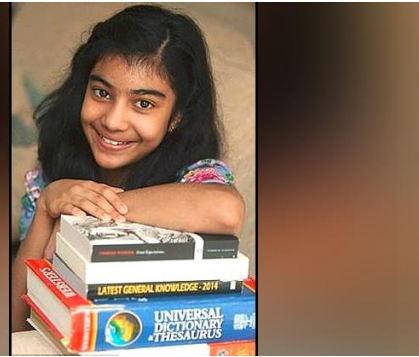
Aadarsh George- Can remember facts

Lydia Sebastian
Mukund Soni, the 10-year-old genius - IQ 162

Aravindh Chithambaram

Kautilya Pandit –
At the mere age of 5, he was able to verbally recall the borders, areas, and other details of every nation in the globe

LIFE AND TIMES OF TERENCE TAO
● Age 7: Begins high school
● 9: Begins university
● 10,11,12: Competes in the International Mathematical Olympiads winning bronze, silver and gold medals
● 16: Honours degree from Flinders University
● 17: Masters degree from Flinders University
● 21: PhD from Princeton University
● 24: Professorship at University of California in Los Angeles
● 31: Fields Medal, the mathematical equivalent of a Nobel prize

SMH GRAPHIC 23.8.06

CONTINUED FRACTIONS
C b OLDS

Shorya Mahanot

Truptraj Pandya

Priyanshi Somani- Mental math

Autistic Savants

Stephen Wiltshire., His IQ score has been measured at 52

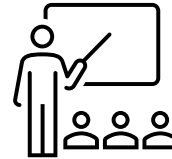Family education, economic status, support

peer

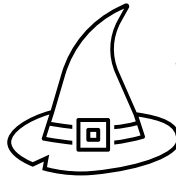Discussions on individual intelligence:

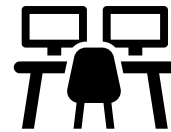Schooling

Nutrition/envirn

Education level

genes

wisdom

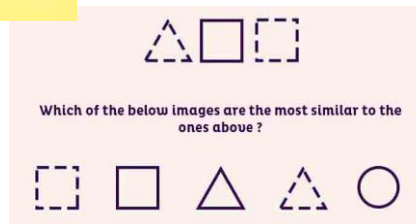Work type

Down history lane….

Early 1900's – Alfred Binet

- such as attention, memory, and problem-solving skills.

But ….

Committee on Provision for Feebleminded - 1916

OBJECTS OF THE COMMITTEE: To disseminate knowledge concerning the extent and menace of feeble-mindedness and to suggest and initiate methods for its control and ultimate eradication from the American people.

Which of the below images are the most similar to the ones above ?

Three Years		Eight Years	
1	Where is your nose, eyes, mouth?	29	Reading and report
2	Repetition of sentences	30	Counting money
3	Repetition of numbers	31	Naming four colors
4	Describing pictures	32	Counting backwards
5	Name of family	33	Writing from dictation
		34	Comparing objects from memory

Four Years | | **Nine Years** | |
6	Sex of child	35	Knowing the date, day, month, day of month, and year
7	Naming familiar objects	36	Reciting days of week
8	Repetition of figures	37	Making change
9	Comparison of lines	38	Definition of familiar objects
		39	Reading and report
		40	Arrangement of weights

Five Years | | **Ten Years** | |
10	Comparison of weights	41	Reciting months of year
11	Copying square	42	Naming nine pieces of money
12	Making rectangle with divided card	43	Sentence building
13	Counting four cents	44	Problem questions

Six Years | | **Eleven Years** | |
14	Indicating right hand, left ear	45	Detecting absurd statements
15	Repetition of sentence	46	Sentence building
16	Esthetic comparison	47	Naming sixty words in three minutes
17	Definition of objects	48	Defining abstract terms
18	Execution of triple order	49	Sentence building
19	Own age		
20	Knowing morning and afternoon		

Twelve Years | |
50	Repetition of figures
51	Rhymes
52	Repetition of sentence
53	Problem questions

Seven Years | | **Thirteen Years** | |
21	Unfinished picture	54	Drawing from design cut in paper
22	Number of fingers	55	Describing figure made from reversed triangle
23	Writing from copy	56	Differences between abstract terms.
24	Copying a diamond		
25	Repetition of figures		
26	Description of pictures		
27	Counting thirteen cents		
28	Naming four common coins		

Why intelligence level was introduced….

+ve :   To help teachers identify and assist children with learning difficulties. To chart child's learning progress.

-ve (govts/policy makers) : selective immigration, segregation, funding, label as mental sub normality (Cyril Burt (1937) with inferences to hereditary.

Definitions – philosophy, psychology, social science……

Plato described the three aspects of the soul as intellectual, emotional and moral; later these were referred to as cognition, affection and conation

Indian views of intelligence (Das, 1994) or buddhi (in Sanskrit) very much involve concepts like wisdom, prudence, emotion, societal values and relations.

Charles Spearman was entirely quantitative, and proposed intelligence to be a 'general ability'. In his book (1927)

Binet equated intelligence with common sense.   1900's: Binet: He called intelligence "judgment…good sense…the faculty of adapting one's self to circumstances." Binet also believed that intelligence is a combination of many skills - skills that are shaped heavily by the environment..

Havighurst (1957) defined talents as extraordinary achievements in one of the following areas: intellectual abilities, creative thinking, scientific abilities, social leadership qualities, mechanical abilities, and artistic

"*intelligence* is the capacity to learn from experience, using metacognitive processes to enhance learning, and the ability to adapt to the surrounding environment; it may require different adaptations within different social and cultural contexts (Niu & Brass, 2011; Saklofske, van de Vijver, Oakland, Mpofu, & Suzuki, 2015; **Sternberg, 2004**)."

So, what exactly can(not) be intelligence?

Over years of research, it has been proposed that :

it is not innate - molded by social-cultural learning.

Not fixed - grows but with constraints (Anderson (1989))

Not general, - multiple intelligences (Das, Kirby and Jarman 1975; Gardner, 1993; Sternberg, 1985a, 1985b).

IQ as measured by standardized tests - does not have a clear relationship with research on cognition.

Hence, intelligence is now regarded as a cluster of cognitive processes, rather than ability.

It is related to information processing comprising among others , attention, plans and strategies (see Sparrow and Davis, 2000, for a review).
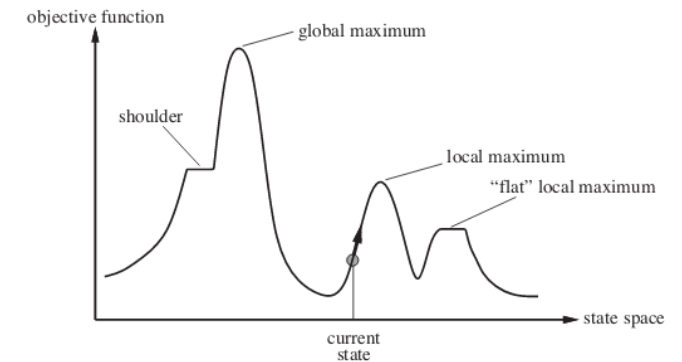
First, Problem-solving

Researchers compare problem solving to a process of *search*, as though you were navigating through a maze, seeking a path toward your goal.

Consider this example: A man is walking down the village road with a tiger, a goat and a bundle of grass. Soon he arrives at the river bank where there is one tiny boat that can carry him and another animal or grass at a time. Here is the problem: Left alone, the tiger will eat the goat. And similarly, the goat will eat the grass bundle. How is he going to take all three across the river safely?

problem-solving heuristic.

1. heuristics are strategies that are efficient but at the cost of occasional errors.

2. In the domain of problem solving, a heuristic is a strategy that narrows your search through the problem space — but (you hope) in a way that still leads to the problem's solution

3. Common heuristics are:

A) Hill-climbing strategy: This strategy is of limited use, however, because many problems require that you briefly move *away* from your goal; only then, from this new position, can the problem be solved.

B) Means-end analysis. In this strategy, you compare your current status to your desired status and ask: "What means do I have to make these more alike?" Among other benefits, this strategy helps you to break a problem into small subproblems.

Problem-solving

Analogy:

Suppose you are a doctor faced with a patient who has a malignant tumor in his stomach. To operate on the patient is impossible, but unless the tumor is destroyed the patient will die. A kind of ray, at a sufficiently high intensity, can destroy the tumor. Unfortunately, at this intensity the healthy tissue that the rays pass through on the way to the tumor will also be destroyed. At lower intensities the rays are harmless to healthy tissue but will not affect the tumor. How can the rays be used to destroy the tumor without injuring the healthy tissue?

Problem –solving by analogy

A dictator ruled a country from a strong fortress, and a rebel general, hoping to liberate the country, vowed to capture the fortress. The general knew that an attack by his entire army would capture the fortress, but he also knew that the dictator had planted mines on each of the many roads leading to the fortress. The mines were set so that small groups of soldiers could pass over them safely, since the dictator needed to move his own troops to and from the fortress. However, any large force would detonate the mines, blowing them up and also destroying the neighboring villages.

The general knew, therefore, that he couldn't just march his army up one of the roads to the fortress. Instead, he devised a simple plan. He divided his army into small groups and dispatched each group to the head of a different road. When all were ready, he gave the signal and each group marched up a different road to the fortress, with all the groups arriving at the fortress at the same time. In this way, the general captured the fortress and overthrew the dictator.

Plausible inference….

Perhaps the people who are better problem solvers are those who make better use of analogies — plausibly, because they pay attention to a problem's deep structure rather than its superficial traits.
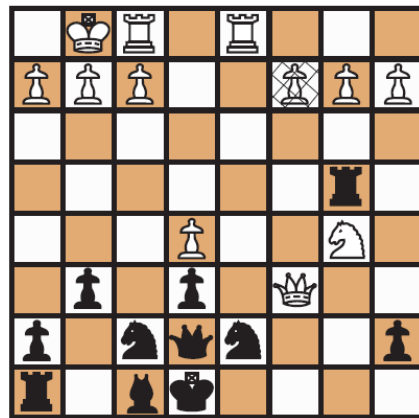
Others:

- intuition

- Incubation

- defining the problem statement clearly

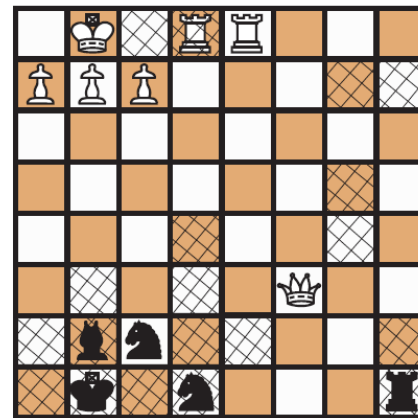- preparation of the information required for solving the problem.

Role of memory
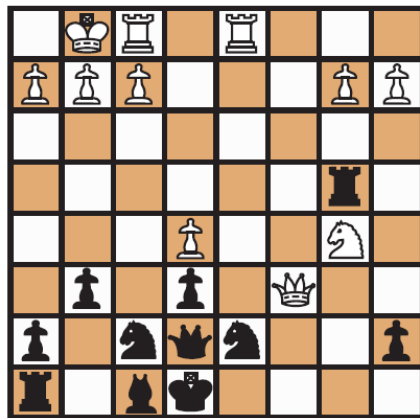
A Actual position
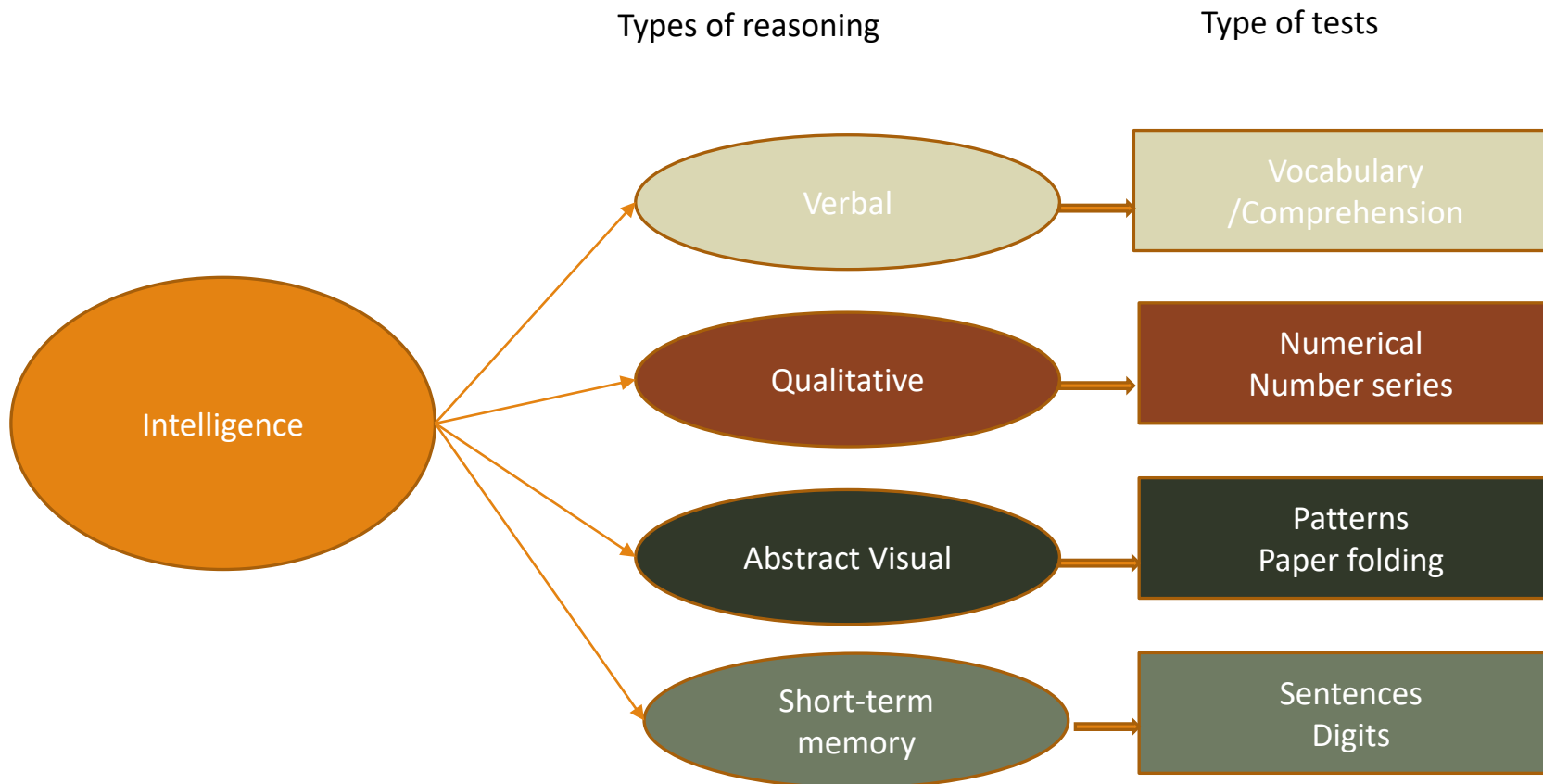
B Typical master player's performance

C Typical average player's performance

Experienced chess players who viewed the pattern in Panel A for 5 seconds were easily able to memorize it (Panel B); average players could not (Panel C), and performance from outright novices was even worse. This is because the experts were able to organize the pattern into meaningful chunks, thereby lightening their memory load. Cross-hatched squares indicate memory errors. (FIG. 8.15 FROM R. BOOTZIN, *PSYCHOLOGY TODAY: AN INTRODUCTION*, 4TH ED. © 1979 MCGRAW-HILL EDUCATION. REPRINTED WITH PERMISSION.)
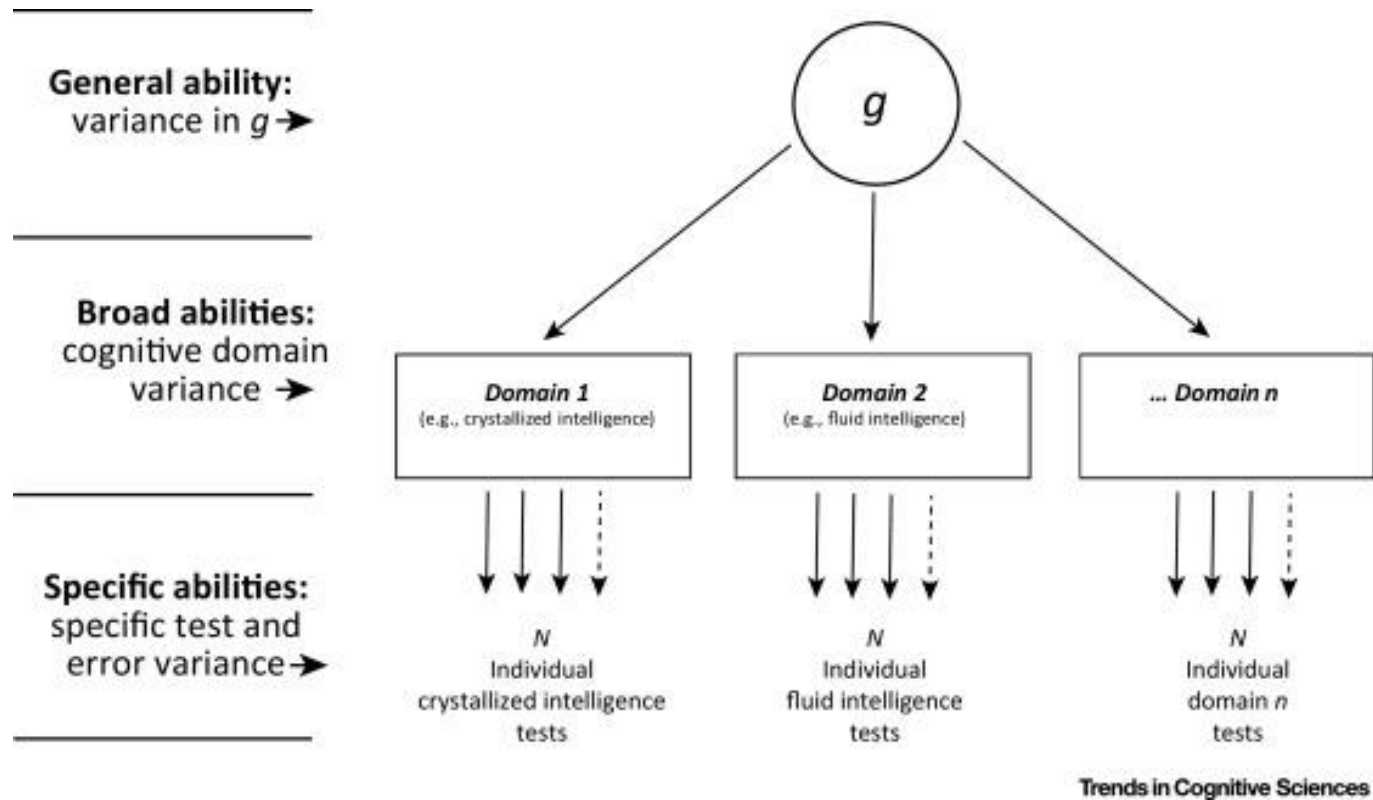
Daniel Reisberg, book: Cognition

Intelligence – how/why do people differ in their cognitive abilities?

So, what are the tests actually measuring?

Qualitative (Binet) to quantitative (Spearman)

Types of reasoning   Type of tests

Intelligence

Types of reasoning	Type of tests
Verbal	Vocabulary /Comprehension
Qualitative	Numerical Number series
Abstract Visual	Patterns Paper folding
Short-term memory	Sentences Digits

Cattell–Horn–Carroll theory

Trends in Cognitive Sciences

Crystalised and Fluid Intelligence

Crystalized Intelligence: tests of prior knowledge and experience

Fluid intelligence: Require adaptive reasoning in novel situations

Others:

Linguistic intelligence

Logical-mathematical intelligence

Spatial intelligence

Musical intelligence

bodily-kinesthetic intelligence

intrapersonal and interpersonal intelligence – what is now termed as emotional/ empathetic intelligence

Emphasises the role of :

Metacognition includes a critical awareness of a) one's thinking and learning and b) oneself as a thinker and learner.

The role of culture (Ang, Van Dyne, & Tan, 2011).

Measure	Example
Abstract-fluid intelligence (Gf)	
DAT-AR	Example A
PMA-R	a b c a b c a b c >>> d a b c x
Verbal-crystallized intelligence (Gc)	
DAT-VR	….. is to water like eating is to ….. (A) Travelling-Driving, (B) Foot-Enemy, (C) Drinking-Bread, (D) Girl-Industry, (E) Drinking-Enemy
DAT-NR	Which number must be substituted by the letter P if the sum is correct? 5P + 2 = 58 (A) 3:(B) 4:(C) 7:(D) 9:(E) None of them
Spatial intelligence (Gv)	
Rotation of solid figures	
DAT-SR	

Figure 1. Examples of classes of mental tasks. DAT, differential aptitude test; AR, abstract reasoning; VR, verbal reasoning; NR, numerical reasoning; SR, spatial reasoning; PMA, primary mental abilities

Reproduced from: Colom et at., 2010

Ravens Progressive Matrices

Carpenter et al; (1990) proposed a set of rules upon which RPM questions have been constructed.

These rules extensively cover all the logic required to solve standard RPM

Rules :

1. constant in a row

2. quantitative pairwise progression

3. distribution of three values

4. figure addition or subtraction

5. distribution of two values.

Studies were done to show RPM was affected by socio-economic scores (Raven , 2000) , gender (Lynn & Irwig ,2004) . Better performance has been proportional to the exposure and resources the kids receive

Fluid Intelligence as tested by Raven's Progressive Matrices

RPM applied in India

Gupta, Mukherjee, and Chatterjee (1993:

Adolescents, in West Bengal.

Sample : 1,453 students from 64 urban and rural schools,

Findings: found wide variations in intellectual level with the mean value being highest for urban boys and lowest for rural girls.

Intelligence scores was found to be highly correlated with academic achievement.

Sudhir and Muraleedharan-Pillai (1987):

Examined science achievement and intelligence scores as a function of socioeconomic status

Secondary school students.

Findings: Higher socioeconomic status plus high IQ obtained higher science achievement scores.

Experiment 1: Critical Analysis of Standard Raven's Progressive Matrices Test for Government and Private School Students

Two schools, a private school, on 103 students (54 boys, 47 girls)

A government school, on 131 students (59 boys, 72 girls). The participants were all in the age group of 9-12 years,
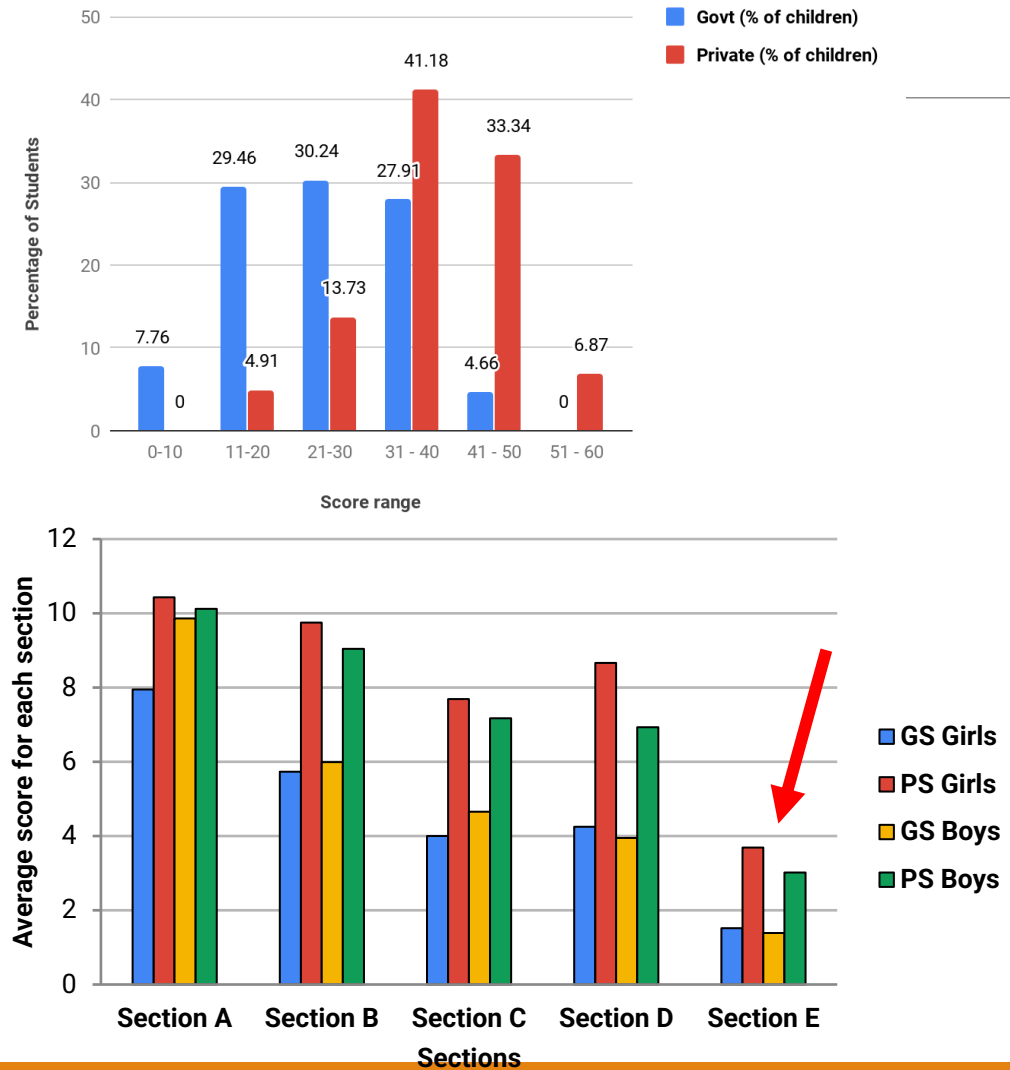
Processes RPM requires…

1. Perceptual

2. Analytical

A Rasch analysis of Sets A to E of RPM concluded that Set A and the first half of Set B measured the perceptual process,

The second half of Set B and Sets C to E measured the analytic process—although other processes were involved in the solution of half the items in Set E (Van der Ven & Ellis, 2000).
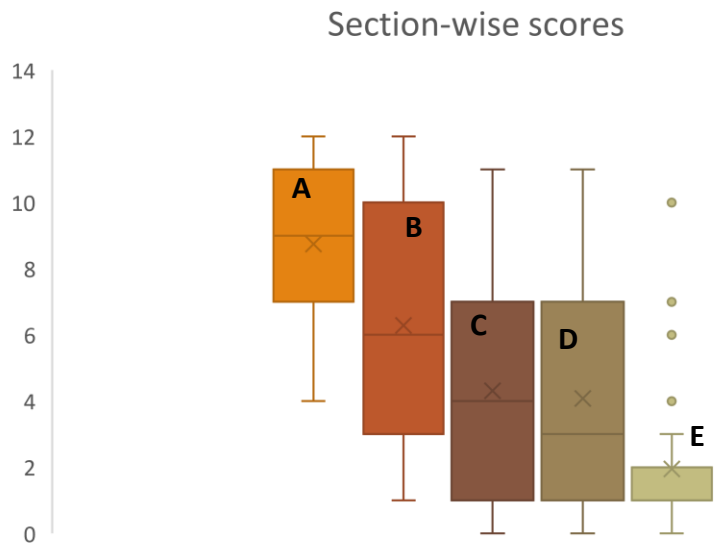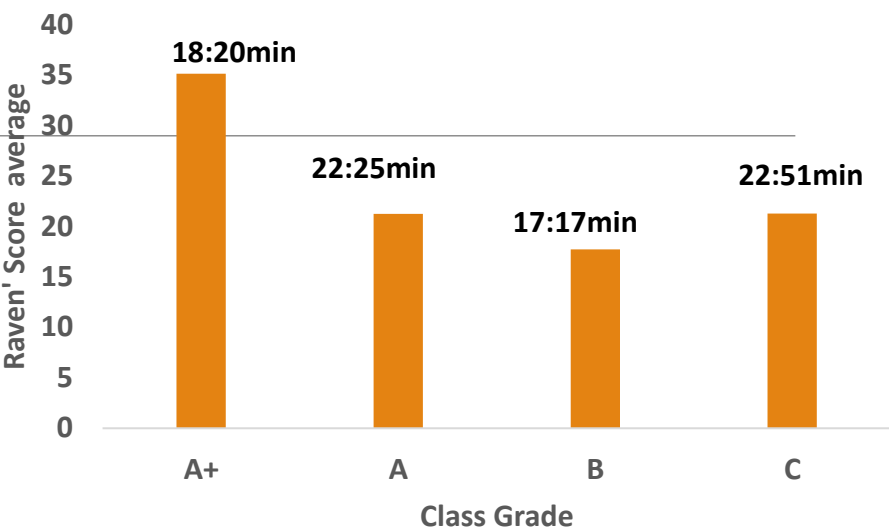
GS	A	B	C	D	E
A	1.000				
B	0.126	1.000			
C	0.232	0.512	1.000		
D	0.325	0.583	-0.001	1.000	
E	0.113	0.210	-0.054	0.341	1.000
PS	A	B	C	D	E
A	1.000				
B	0.553	1.000			
C	0.523	0.643	1.000		
D	0.451	0.572	0.625	1.000	
E	0.395	0.588	0.583	0.576	1.000

Experiment 2: PERFORMANCE ANALYSIS WITH ACADEMIC GRADE POINT

KV School – nearly equal distribution in terms of socio-economics

Participants: 39 (girls = 13)

Class 5

Section-wise scores

A & A+: The z-score is 2.47487. The p-value is .01352. The result is significant at $p < .05$

Gender-wise scores: boys (26.48) > girls (23.07)
The z-score is 2.47487. The p-value is .01352. The result is significant at $p < .05$.

The RPM's top scorers (>40) were all A+, while for <40 there was no dominent trend.
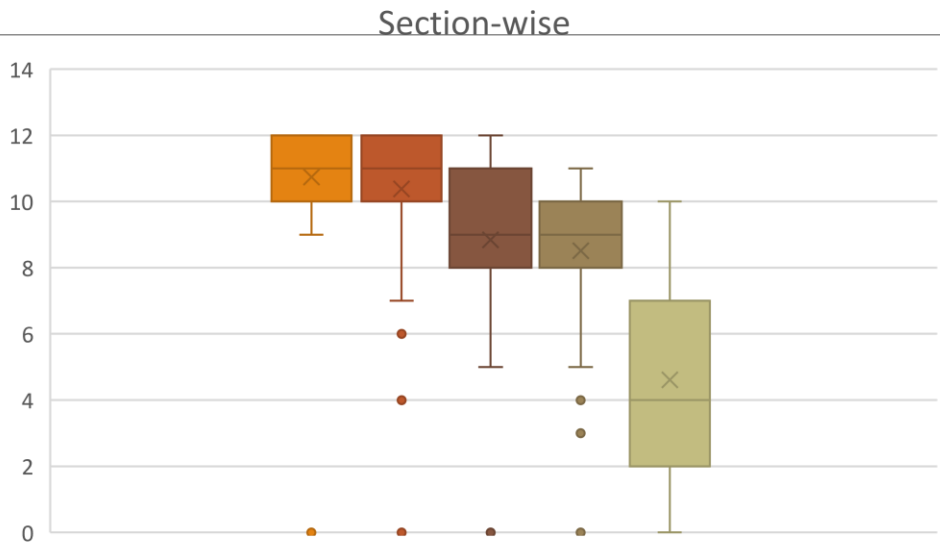
Participants:39 (boys = 25)

Class: 4th,5th & 6th

All school toppers (A+) graders, expensive private school

Average time: 15 min

Gender wise score : Boys = 44.84 ± 6.4915

Girls = 44.28 ± 8.164

Section-wise

RPM and patterns in Nature

Version-1 Vs Version-2

- ❖ The game-app had 6 levels and each level consisted of 5 questions. An image (examples below) was presented with correct number options of patches in a side panel (Version-1).
- ❖ The player had to select each of these patches and move it to the gap in the image. A correct pattern matching is given a score while time taken to complete the task is recorded.
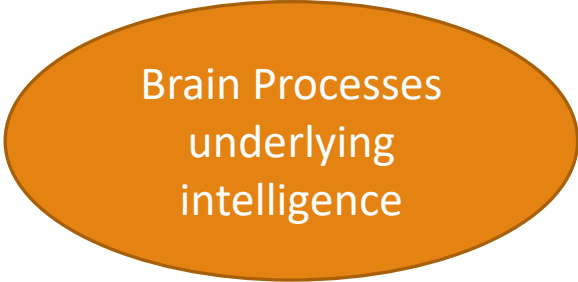- ❖ In some levels the patches were inverted patterns (Version-2).

LIMITATIONS AND FUTURE WORK

- ❖ The participants sample size was too small to make strong inferences.
- ❖ The patterns as in RPM and the natural images selected needed to be correlated and feature matched.
- ❖ The images selected for the game-app have to be standardized for visual balance, color hue sensitivity, light/retinal illuminance and many other human visual system factors that might influence the matching.
- ❖ The role of timer related stress should also be weighted to the score.
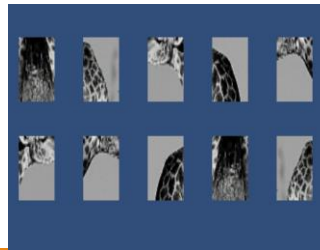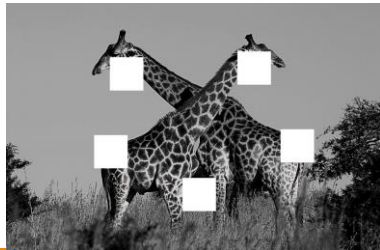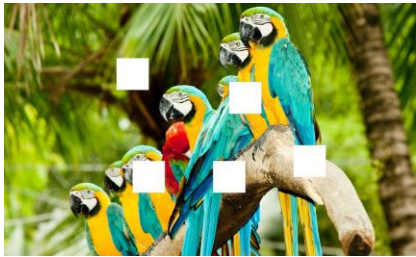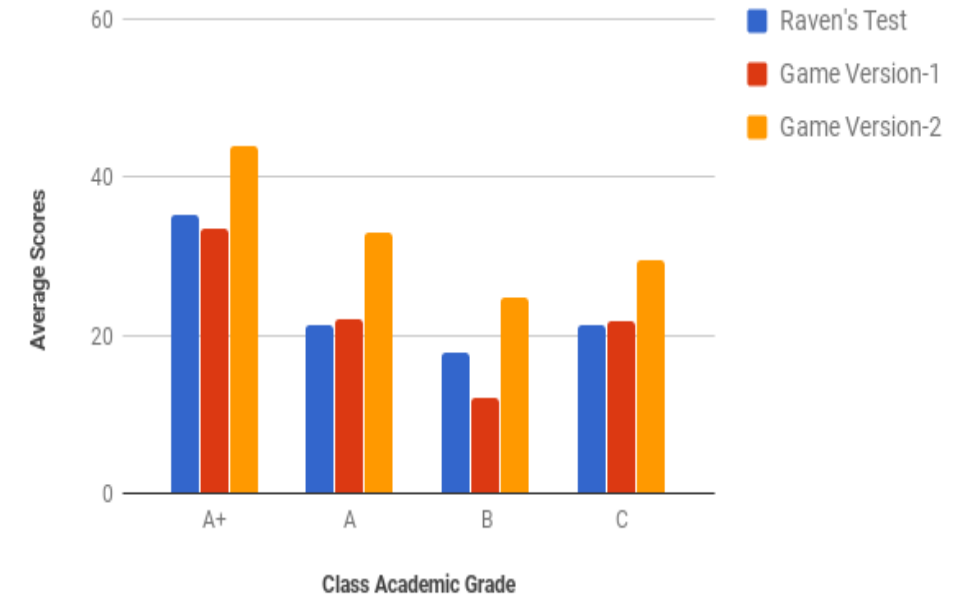
Brain Networks of Intelligence

Brain Processes underlying intelligence

RPM – initial fMRI studies

Prabhakaran et al 1997:

Right frontal and bilateral parietal regions were activated more by figural than control problems.

Bilateral frontal and left parietal, occipital, and temporal regions were activated more by analytic than figural problems.

Many of these activations occurred in regions associated with working memory.
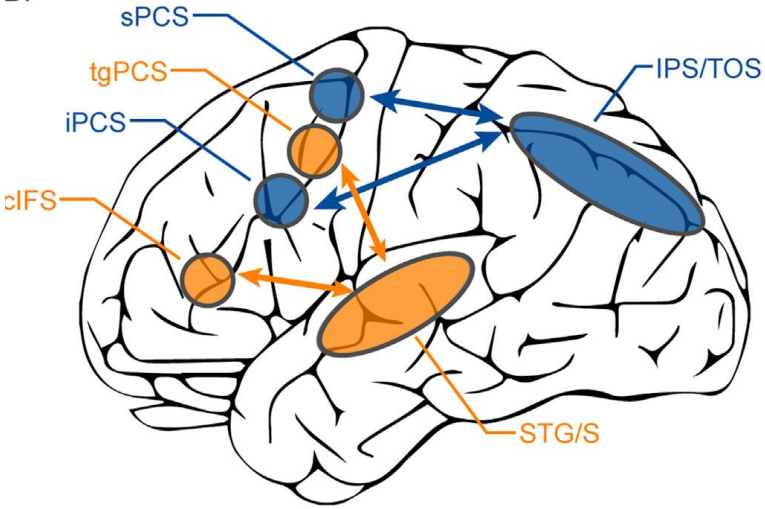
Figural reasoning activated areas involved in spatial and object working memory.

Analytic reasoning activated additional areas involved in verbal working memory and domain-independent associative and executive processes.
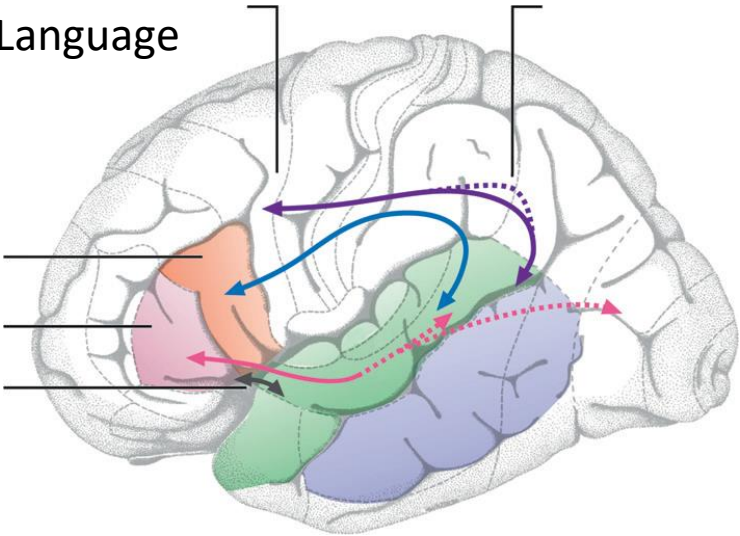
 These results suggest that fluid reasoning is mediated by a composite of working memory systems

Visual- vs. auditory-biased attention networks from Michalka et al. (2015).. Visual (Blue) and Auditory (orange)

B.
sPCS
tgPCS
iPCS
cIFS
IPS/TOS
STG/S

Working memory model (Baddeley, 2010)

ACC: Attention Controller
Parietal Lobe: Episodic Buffer (perceptual processing)
Prefrontal Cortex: Central Executive
Broca's & Wernicke's: Phonological Loop
Occipital Lobe: Visuo-spatial Sketch-pad

Language

Intelligence tests

7, 40
9, 6
32
10
46, 45 47
39
19, 18
21, 37

Angela D Friedericia nd Sarah ME Gierhan, Current Opinion in Neurobiology, 2013

Daniel Reisberg, book: Cognition
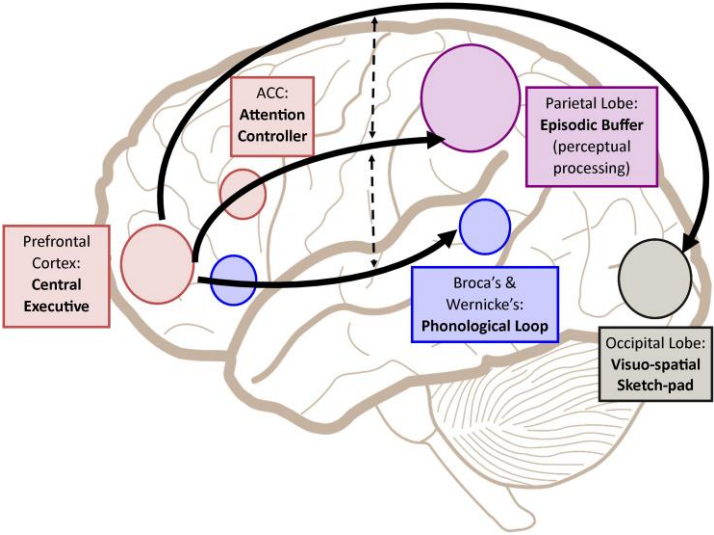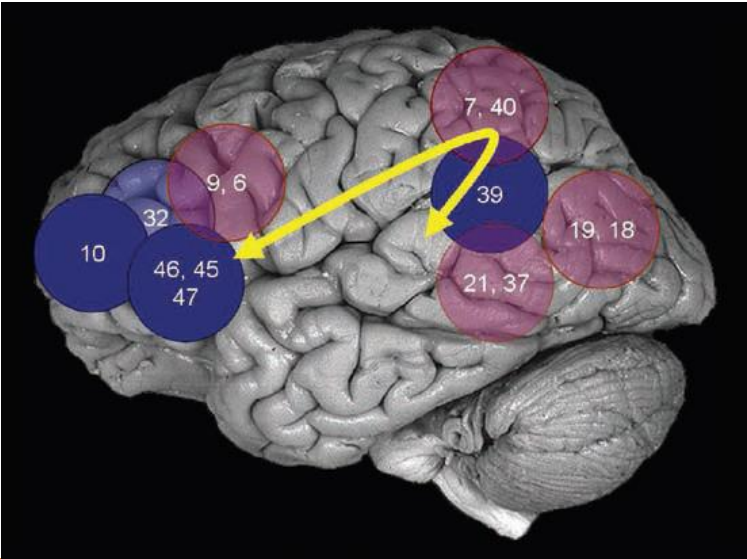
(A) Intrinsic connectivity networks
(i) (ii) (iii)

(B) Network flexibility

(i) **Crystallized intelligence**
Percent of regions within each ICN that can transition to **easily reachable states**

Default mode Network: 30%

(ii) **Fluid intelligence**
Percent of regions within each ICN that can transition to **difficult-to-reach states**

Cognitive control Networks: 32%

Key:
- Default mode
- Frontoparietal
- Cingulo-opercular
- Ventral attention
- Dorsal attention
- Other
- Auditory
- Visual
- Somatosensory

A growing body of evidence suggests that individual differences in crystallized and fluid intelligence reflect global, system-wide dynamics and the capacity to flexibly transition between network states.

Cingulo-opercular network: ACC, Anterior Insula, & Thalamus

Trends in Cognitive Sciences

The Mantra for Sustainability – in all discussions on testing.

Learning Practice : According to various estimations (e.g., Ericsson,1998), these add up over time to a total of about 10,000 hours of intensive learning practice (action repertories).

The role of goals: actions in a specific domain are governed by various goals. Teachers/parents can set goals for the children. *For example: start from 2 problems in math a day to 10 by end of the month*.

Environment : Knowledgeable about the enormous degree of organization inherent in the learning process, need to study the environment that plays an immense role – *teachers/parents can create an open uncritical atmosphere.*

Creative minds…the mantra

- Creative individuals generally have great knowledge and skills in their domain & extended applications.

- certain personality traits: a willingness to take risks, a willingness to ignore criticism, an ability to tolerate

  ambiguous findings or situations, and an inclination not to "follow the crowd."

- highly creative people tend to be motivated by the pleasure of their work rather than by the promise of external rewards.

- Highly creative people tend to work extremely hard on their endeavors and to produce

  a lot of their product

Thank you….