

Intelligence and aptitude

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1. Theories of intelligence, emotional and artificial intelligence
2. Measuring intelligence and aptitude; giftedness and intellectual disability

1 Theories of intelligence, emotional and artificial intelligence

Intelligence is the global capacity to understand the world, think rationally and use resources well when faced with challenges; psychometric theories describe it as one or more factors found by factor analysis (Spearman's *g*, Thurstone's 7 PMAs, Guilford's cube, Cattell's *Gf-Gc*), information-processing theories describe the processes an intelligent person uses (Sternberg, PASS), and the idea has widened to multiple, emotional and artificial intelligence.

Core facts

- **Definitions** (Binet, Terman, Stern, Wechsler, Thorndike's three kinds) and the B.Ed.-style theory list: see **EDU-ID-01**. This note adds the BA-level points the Paper II asks.
- **NCERT's working definition:** the global capacity to **understand** the world, **think rationally** and **use available resources effectively** when faced with challenges.
- **Indicators of intelligence:** judging well, reasoning well, understanding, solving problems, **adapting to the environment**, learning from experience. "Listening well" is **not** an indicator (2023 key).
- **Approaches** (three are named in Indian BA texts, and the 2023 key accepted all three):
 - **Psychometric:** intelligence as an aggregate of abilities, shown as one score (IQ); found by **factor analysis** of test scores.
 - **Structural:** the psychometric theories seen as maps of the *structure* of abilities (*g* at the top, group and specific factors below, or Guilford's cube).
 - **Information-processing:** the **processes** people use in reasoning and problem solving; its focus is **how an intelligent person acts** (2023 A-R item).

Theorist-theory table

Theorist	Theory / model	Year	Core of it
Alfred Binet	Uni-factor	1905	one general ability ("good sense")
Charles Spearman	Two-factor	1904	g (general) + s (specific)
E.L. Thorndike	Multi-factor	1920s	many separate bonds; abstract, social, mechanical
Godfrey Thomson	Sampling	1916	each test samples many small abilities
L.L. Thurstone	Primary mental abilities	1938	7 group factors, no single <i>g</i>
P.E. Vernon (after Burt)	Hierarchical	1950	<i>g</i> → v:ed, k:m → minor → specific
Arthur Jensen	Hierarchical, two levels	1969	Level I associative, Level II cognitive

Theorist	Theory / model	Year	Core of it
J.P. Guilford	Structure of intellect	1967	operations × contents × products = 120
R.B. Cattell (with J. Horn)	Fluid and crystallised	1940s–60s	Gf reasoning, Gc knowledge
Howard Gardner	Multiple intelligences	1983	7, later 8 independent intelligences
Robert Sternberg	Triarchic	1985	componential, experiential, contextual
J.P. Das , Naglieri, Kirby	PASS	1994	planning, attention, simultaneous, successive

- **Thurstone's 7 PMAs:** verbal comprehension, word fluency, number, space, memory, perceptual speed, reasoning.
- **Gardner's eight**, each in one line:
 - **Linguistic:** using language fluently and flexibly.
 - **Logical-mathematical:** abstract reasoning, symbols, number, logic.
 - **Spatial: forming, using and transforming mental images** (2023 key).
 - **Musical:** sensitivity to pitch, rhythm and tone.
 - **Bodily-kinaesthetic:** using the whole body or hands skilfully.
 - **Interpersonal:** understanding other people's motives and feelings.
 - **Intrapersonal:** knowing one's own feelings, strengths and identity.
 - **Naturalist:** recognising plants, animals and patterns in nature (added later, 1990s).
- **Sternberg's three: componential = analytical, experiential = creative, contextual = practical** ("street smart").
- **PASS** rests on **A.R. Luria's** three functional units of the brain; tested by the **Cognitive Assessment System (CAS)**.
- **Emotional intelligence (EI): Salovey and Mayer (1990)** first defined it; **Goleman (1995)** popularised it with five components. Models, branches and tests: see **MAB-EI-01**.
- **Artificial intelligence (AI):** term coined by **John McCarthy** for the **Dartmouth conference, 1956**. **Alan Turing's** test of machine intelligence: 1950.
- **Connectionism** = explaining the mind by **artificial neural networks** of simple connected units; **parallel distributed processing (PDP)** is its main model (**Rumelhart and McClelland, 1986**) (2023 key).

Explained

1. Psychometric vs information-processing, side by side

	Psychometric	Information-processing
Asks	how much, and which abilities	how a person thinks
Method	factor analysis of test scores	analysing steps of a task

	Psychometric	Information-processing
Output	IQ, factor scores	process profile (e.g. PASS)
Theories	Spearman, Thurstone, Guilford, Cattell	Sternberg, Das (PASS)

Gardner's theory is usually taught with the modern "multiple abilities" views; it rests on evidence from brain damage, prodigies and savants, not on factor analysis.

2. From one factor to many. Spearman noticed that people who do well on one mental test tend to do well on others (positive correlations) and called the common part **g**; the leftover skill for each test is **s**. Thurstone's own factor analysis of many tests gave **seven** fairly separate factors instead of one **g**, and he built the PMA test on them. Thomson said a test score samples many small independent abilities, so correlations arise from overlap, not from one **g**. The **hierarchical** models reconcile the two: **Vernon** put **g** at the top, then two major group factors, **v:ed** (verbal-educational) and **k:m** (practical-mechanical-spatial), then minor group factors and specific factors.

3. Jensen's two levels (the 2023 match item called him "Jansen")

- **Level I, associative learning:** the output is much like the input; rote memory, digit span.
- **Level II, cognitive competence:** the input is transformed; reasoning, abstraction, problem solving.

Jensen argued all groups are alike in Level I, and that Level II tracks **g**; his claims about group differences were strongly disputed.

4. Guilford's cube. Three faces: **operations** (what the mind does: cognition, memory, divergent production, convergent production, evaluation), **contents** (what it works on: figural, symbolic, semantic, behavioural) and **products** (the form of the result: units, classes, relations, systems, transformations, implications). $5 \times 4 \times 6 = 120$ abilities (1967). Splitting figural content into visual and auditory gives $5 \times 5 \times 6 = 150$, the figure NCERT gives; a later split of memory gives 180. Full table: **EDU-ID-01**. Divergent production is the root of creativity (see **EDU-ID-03**).

5. Cattell's fluid and crystallised intelligence

- **Fluid (Gf):** solving new problems, seeing relations, culture-light; tied to the nervous system; rises to the 20s, then slowly falls.
- **Crystallised (Gc):** vocabulary, facts and skills from schooling and culture; keeps growing into late adulthood.

Culture-fair tests (Raven's, Cattell's own Culture Fair Test) try to tap **Gf**. The later **Cattell-Horn-Carroll (CHC)** model joins this with Carroll's three-stratum model (1993).

6. Sternberg's triarchic theory, in detail

Sub-theory	Intelligence	What it does	Example
Componential	Analytical	analyse, compare, judge	topper in exams
Experiential	Creative	deal with new tasks; make old ones automatic	inventor, artist
Contextual	Practical	adapt to, shape or select the environment	successful trader

Components are of three kinds: **metacomponents** (plan, monitor, evaluate), **performance components** (carry out the plan) and **knowledge-acquisition components** (learn new things). Sternberg later called the balance of all three **successful intelligence**.

7. PASS model

Process	What it does	Luria's unit / brain area
Attention-arousal	stay alert, attend to the right stimuli	unit 1: brain stem, reticular system
Simultaneous	combine parts into a whole (patterns, relations)	unit 2: occipital-parietal
Successive	handle items in serial order (sequences, speech)	unit 2: fronto-temporal
Planning	choose, use and check strategies	unit 3: frontal lobes

Too much or too little arousal hurts performance. Planning is the central, "executive" process. Das, born in Odisha, did most of this work at the University of Alberta, Canada; the CAS is used to diagnose learning difficulties.

8. Heredity and environment. Twin and adoption studies (as reported by NCERT): IQ correlation is about **0.90** for identical twins reared together, **0.72** for identical twins reared apart, about **0.60** for fraternal twins reared together, **0.50** for siblings reared together and **0.25** for siblings reared apart. Adopted children grow closer to their **biological** parents' IQ with age. Yet deprivation lowers IQ and enrichment (nutrition, schooling, stimulating homes) raises it: **heredity sets a range, environment decides where in it a person falls**.

9. Culture and intelligence. Western tests stress speed, analysis and abstract reasoning ("**technological intelligence**"). NCERT describes an Indian **integral** view (**buddhi**) that joins knowledge with self-reflection and social ties, under four competencies: **cognitive capacity, social competence, emotional competence, entrepreneurial competence**. Sternberg calls intelligence **contextual**: what counts as intelligent depends on the culture.

10. Emotional intelligence (short; full note MAB-EI-01). EI = the ability to perceive, understand, use and manage one's own and others' emotions. The emotionally intelligent person reads feelings from body language and voice, links emotions to thoughts, and controls strong emotions. **Applications:** counselling and probation work (managing anger, empathy with offenders and victims), leadership and teamwork at work, emotional-literacy and life-skills programmes in schools. Unlike IQ, EI can be **trained**.

11. Artificial intelligence: two traditions

	Symbolic AI	Connectionism
Model of mind	rules acting on symbols	network of simple units
Knowledge stored in	explicit rules, facts	strengths (weights) of connections
Processing	serial, step by step	parallel, distributed
Examples	Logic Theorist, GPS, expert systems	perceptron, PDP models, deep learning

- **PDP:** many simple units work **at the same time**; a memory or concept is a **pattern spread across many units**, not stored in one place; the network **learns** by adjusting weights from experience (e.g.

back-propagation, 1986). Such networks recognise patterns, generalise, and degrade gracefully when damaged, like the brain.

- **Milestones:** McCulloch and Pitts' model neuron (1943); Turing test (1950); Dartmouth, McCarthy (1956); Newell and Simon's **Logic Theorist** (1956) and **General Problem Solver** (1957); Rosenblatt's **perceptron** (1958); **ELIZA** (Weizenbaum, 1966), a program that imitated a non-directive therapist; expert systems such as **MYCIN** (1970s, medical diagnosis); PDP volumes (1986); today's deep learning and large language models.
- **Applications for psychology:** computer simulation to test theories of thinking and memory; expert systems and computer-based (adaptive) testing; tutoring systems; screening and support chatbots in mental-health care; robots and aids for the disabled.

Common traps

✗ "The information-processing approach measures how much intelligence a person has." ✓ It studies **how** an intelligent person thinks and acts; "how much" is the **psychometric** approach.

✗ "Jensen gave the triarchic theory." ✓ Jensen = **hierarchical, Level I and Level II**; **Sternberg** = triarchic.

✗ "Vernon's model has primary mental abilities." ✓ Vernon = **hierarchical (g, v:ed, k:m)**; **Thurstone** = PMAs.

✗ "Binet gave a multi-factor theory." ✓ Binet's view is **uni-factor** (one general ability); multi-factor = **Thorndike**.

✗ "Fluid intelligence grows with education into old age." ✓ That is **crystallised**; fluid peaks in early adulthood.

✗ "Spatial intelligence is skill with the body." ✓ Spatial = **forming, using and transforming mental images**; body = **bodily-kinaesthetic**.

✗ "PASS stands for perception, attention, speed, sequence." ✓ **Planning, Attention-arousal, Simultaneous, Successive** (J.P. Das).

✗ "PDP belongs to neural networking / associationism as its paradigm." ✓ The paradigm is **connectionism**.

✗ "Goleman coined emotional intelligence." ✓ **Salovey and Mayer (1990)**; Goleman (1995) popularised it.

✗ "Turing coined the term artificial intelligence." ✓ **John McCarthy**, 1956; Turing proposed the **test** (1950).

Quick revision

- Approaches: psychometric (how much; factors), structural, information-processing (how one thinks and acts).
- Binet uni; Spearman 1904 g + s; Thorndike multi; Thomson sampling; Thurstone 1938 seven PMAs.
- Hierarchical: Vernon 1950 (g, v:ed, k:m); Jensen 1969 Level I associative, Level II cognitive.
- Guilford 1967: 5 operations × 4 contents × 6 products = 120 (NCERT 150).
- Cattell: fluid (new problems, falls with age) vs crystallised (knowledge, keeps rising).
- Gardner 1983: 7 + naturalist = 8; spatial = mental images.
- Sternberg 1985: analytical (componential), creative (experiential), practical (contextual).
- PASS (Das, Naglieri, Kirby; Luria): planning, attention, simultaneous, successive; CAS.
- EI: Salovey and Mayer 1990, Goleman 1995 (MAB-EI-01).
- AI: McCarthy 1956, Turing test 1950; connectionism = neural networks; PDP = Rumelhart and McClelland 1986.

2 Measuring intelligence and aptitude; giftedness and intellectual disability

Intelligence tests began with Binet and Simon (1905), gave us mental age and the $IQ = MA \div CA \times 100$, and moved to Wechsler's deviation IQ (mean 100, SD 15); aptitude tests predict how well a person can learn a particular skill; at the two ends of the IQ curve stand the gifted (about 130 and above) and the intellectually disabled (IQ below 70, with poor adaptive behaviour, starting before 18).

Core facts

- The B.Ed.-level basics (Binet-Simon, Stern, Terman, Wechsler scales, verbal/non-verbal, individual/group tests, Terman's old IQ table): see **EDU-ID-01**. Slow learners, Terman's gifted study, Renzulli, education of the gifted and the RPwD Act: see **EDU-ID-03**. This note adds what the Psychology Paper II asks.
- **Francis Galton**: first tried to measure intelligence through **sensory and reaction-time** tests (anthropometric laboratory, London, **1884**). **James McKeen Cattell** coined the term "**mental test**" (**1890**).
- **Alfred Binet** (with **Theodore Simon**) built the **first intelligence test, 1905**, to find Paris children who needed special schooling.
- **Mental age (MA)**: the level of performance of an average child of a given age; brought in with the **1908** revision. Binet and Simon took a child whose MA was **two years below** his chronological age as **retarded** (2023 key).
- **William Stern (1912)** proposed the **mental quotient**; **Lewis Terman** used **IQ** in the **Stanford-Binet (1916)**.
- **$IQ = (MA \div CA) \times 100$** . Multiplying by 100 is done **to avoid decimals** (2023 key). MA 12, CA 10 → IQ 120.
- **Deviation IQ (Wechsler)**: a person's score compared with others of the **same age**, scaled to **mean 100, SD 15**: $IQ = 100 + 15z$. One SD above the mean = **115**; two SD below = **70**.
- **Wechsler scales**: Wechsler-Bellevue **1939**, **WISC 1949** (children), **WAIS 1955** (adults), **WPPSI 1967** (pre-school). Gave a **verbal**, a **performance** and a **full-scale IQ**.
- **Army Alpha (verbal) and Army Beta (non-verbal)**, USA, **1917**, group tests for recruits, under **Robert Yerkes**.
- **Culture-fair tests**: **Raven's Progressive Matrices** (1938), **Cattell's Culture Fair Intelligence Test**, **Goodenough's Draw-a-Man test** (1926).
- **Indian tests**: C.H. **Rice** (Hindustani Binet, 1920s), V.V. **Kamat** (Binet in Kannada and Marathi, 1930s), C.M. **Bhatia's** Battery of Performance Tests (**1955**), A.J. **Malin's** Intelligence Scale for Indian Children (**MISIC**, an adaptation of WISC), S.S. **Jalota's** group test.
- **Aptitude** = a set of characteristics showing a person's **potential to acquire a specific skill with training** (Bingham). **Aptitude + interest** give the best chance of success.

- **Aptitude tests:** special (one area) and **multiple aptitude batteries:** **Differential Aptitude Tests (DAT)**, Bennett, Seashore and Wesman, **1947**; Indian adaptation by J.M. Ojha) and the **General Aptitude Test Battery (GATB)**, US Employment Service, 1947).

IQ classes and share of people (NCERT, Wechsler-type labels)

IQ	Description	Share
above 130	very superior	2.2%
120-130	superior	6.7%
110-119	high average	16.1%
90-109	average	50.0%
80-89	low average	16.1%
70-79	borderline	6.7%
below 70	intellectually disabled	2.2%

- **Giftedness:** exceptional general ability shown across many areas; usually **IQ above 130**. **Talent:** a remarkable ability in one specific field (music, sport).
- **Gifted children show:** advanced reasoning and questioning; fast information processing; good generalisation; originality; **long attention span**; strong **recognition memory**; high intrinsic motivation; **independent, non-conformist thinking**; liking for solitary academic work. **Conformist thinking is not** a trait (2023 key).
- **Intellectual disability** (old term **mental retardation**), AAMD/AAIDD: **significantly below-average intellectual functioning (IQ about 70 or below)** together with **deficits in adaptive behaviour**, appearing in the **developmental period (0 to 18 years)** (2023 keys: **IQ below 70; 0–18**).
- **AAMD** = American Association on Mental Deficiency → **AAMR** (1987, Mental Retardation) → **AAIDD** (2007, Intellectual and Developmental Disabilities).

Levels of intellectual disability

Level	IQ (about)	Share of cases	What the person can do
Mild ("educable")	50/55–70	about 85%	school skills to about class 6; work, live independently, marry and raise a family with little support
Moderate ("trainable")	35/40–50/55	about 10%	self-care, speech, simple routine work in sheltered settings
Severe	20/25–35/40	3–4%	basic self-care and simple speech after long training; close supervision
Profound	below 20/25	1–2%	constant care; little or no speech; often physical problems too

Explained

1. Ratio IQ vs deviation IQ

	Ratio IQ	Deviation IQ
Formula	$MA \div CA \times 100$	$100 + 15 \times (\text{score} - \text{age mean}) \div \text{age SD}$
Meaning	pace of mental growth	standing among age-mates
Works for adults?	no : MA stops rising in mid-teens	yes
Used by	early Stanford-Binet	Wechsler, all modern tests

Example of the adult problem: a 40-year-old with an adult-level MA of 16 would get IQ 40 by the ratio formula; the deviation IQ avoids this by comparing him only with other 40-year-olds.

2. Reading a deviation IQ on the normal curve. About **68%** of people score **85–115**, about **95%** score **70–130**, and about **99.7%** score **55–145**. IQ 115 $\approx$ 84th percentile; 130 $\approx$ 98th; 70 $\approx$ 2nd.

3. Kinds of tests, with the right example

Kind	Who it suits	Example
Individual verbal	literate person, diagnosis	Stanford-Binet, Wechsler verbal
Individual performance	young, illiterate, deaf, other language	Kohs blocks, Alexander pass-along, Bhatia
Group verbal	quick screening of literates	Army Alpha, Jalota
Group non-verbal	mixed or illiterate groups	Army Beta, Raven's matrices

Individual tests are more **accurate and diagnostic**; group tests are **cheaper and quicker** but give less information about one person. Culture-fair tests cut down language and schooling, but no test is fully free of culture: even pictures and puzzles are more familiar to some groups.

4. Intelligence, aptitude, achievement, interest

Test	Measures	Looks	Example
Intelligence	general mental ability	broad, future	WAIS, Raven's
Aptitude	potential in one area	future (with training)	DAT, clerical test
Achievement	what has been learnt	past (after training)	class test, board exam
Interest	likes and dislikes	choice of field	Strong, Kuder inventories

5. Aptitude tests in more detail

- **Special aptitude tests: mechanical** (Bennett Mechanical Comprehension Test), **clerical** (Minnesota Clerical Test: checking numbers and names fast), **musical** (Seashore Measures of Musical Talents, 1919), **artistic** (Meier Art Judgment Test), and tests for teaching, medicine, law and engineering entrance.
- **DAT, eight sub-tests:** verbal reasoning, numerical ability, abstract reasoning, clerical speed and accuracy, mechanical reasoning, space relations, spelling, language usage. A profile of eight scores is

used in **educational and vocational guidance** (choice of stream or job).

- **Uses:** selection for jobs and courses, placement and training, career counselling, and in correctional homes, vocational training matched to an inmate's aptitude.

6. Intellectual disability: the three parts of the definition

1. **Intellectual functioning** well below average: about two SD below the mean (IQ about 70, allowing 70–75 for test error).
2. **Adaptive behaviour** deficits in **conceptual** (language, money, time), **social** (relationships, following rules, avoiding being cheated) and **practical** (self-care, work, travel, safety) skills. Measured by scales such as the **Vineland Social Maturity Scale** (Edgar Doll, 1935), which gives a **social quotient (SQ) = social age ÷ CA × 100**; Indian adaptation by A.J. Malin.
3. **Onset in the developmental period**, before **18**.

A low IQ alone is not enough: a person with IQ 68 who manages daily life, work and money well is **not** diagnosed. **DSM-5 (2013)** sets the level (mild to profound) by **adaptive functioning**, not by IQ alone.

7. Causes of intellectual disability

- **Genetic / chromosomal:** **Down syndrome** (trisomy 21; the most common chromosomal cause), **fragile X syndrome** (the most common inherited cause), **phenylketonuria (PKU)** (preventable by diet if screened at birth).
- **Prenatal:** maternal infections (rubella, toxoplasmosis), **alcohol (fetal alcohol syndrome)**, drugs, malnutrition, **iodine deficiency (cretinism)**, radiation.
- **Perinatal:** lack of oxygen at birth, very premature birth, birth injury.
- **Postnatal:** meningitis, encephalitis, head injury, lead poisoning, severe malnutrition, gross social and cultural deprivation.

Most mild cases have no single known biological cause and are linked with poverty and deprivation; most severe and profound cases have a clear organic cause.

8. Helping each group

- **Gifted:** acceleration, enrichment, mentoring, special programmes (detail in **EDU-ID-03**); watch for boredom, under-achievement and isolation.
- **Intellectually disabled:** early identification and stimulation, special or inclusive education with an individual plan, **vocational training** and sheltered workshops, behaviour modification for self-care, family counselling. The **RPwD Act 2016** lists intellectual disability (including specific learning disabilities and autism spectrum disorder in its Schedule) among the 21 disabilities.

Common traps

✗ "IQ = CA ÷ MA × 100." ✓ **IQ = MA ÷ CA × 100**; × 100 is there **to avoid decimals**.

✗ "Terman built the first intelligence test." ✓ **Binet and Simon, 1905**; Terman made the **Stanford-Binet, 1916**.

✗ "Ratio IQ works for adults." ✓ It fails after the mid-teens; adults get a **deviation IQ** (mean 100, SD 15).

✗ "Aptitude tests measure what has already been learnt." ✓ That is **achievement**; aptitude predicts **future** learning with training.

✗ "DAT is a test of general intelligence." ✓ DAT is a **multiple aptitude battery** (8 sub-tests).

✗ "AAMD cut-off is IQ 75–80." ✓ **Below 70** (about 2 SD below the mean), **plus** adaptive-behaviour deficits.

✗ "The developmental period for diagnosis is 0–16 years." ✓ **0–18 years** (standard answer).

✗ "Moderately disabled people hold jobs and raise families." ✓ That is **mild** ("educable"); moderate = "trainable", sheltered work.

✗ "Gifted children are conformist thinkers." ✓ They are **independent, non-conformist** thinkers.

✗ "Raven's matrices is a verbal test." ✓ **Non-verbal, culture-fair** group test.

Quick revision

- Galton 1884 sensory tests; J.M. Cattell "mental test" 1890; Binet-Simon 1905; MA 1908.
- Binet: MA two years below CA = retarded; Stern 1912 quotient; Terman Stanford-Binet 1916 "IQ".
- $IQ = MA \div CA \times 100$ ($\times 100$ avoids decimals); deviation IQ mean 100, SD 15.
- Wechsler-Bellevue 1939, WISC 1949, WAIS 1955, WPPSI 1967; Army Alpha (verbal) and Beta (non-verbal) 1917.
- Culture-fair: Raven's 1938, Cattell CFIT, Draw-a-Man; India: Bhatia 1955, MISIC, Jalota.
- Aptitude = potential with training (future); achievement = past learning; DAT 8 sub-tests, GATB.
- Average 90–109 (50%); above 130 very superior/gifted; below 70 intellectually disabled (2.2% each).
- ID = IQ below 70 + adaptive deficits + onset before 18 (AAMD → AAMR → AAIDD).
- Mild 50–70 educable, independent living; moderate 35–50 trainable; severe 20–35; profound below 20.
- Causes: Down syndrome, fragile X, PKU, rubella, alcohol, iodine lack, birth asphyxia, deprivation.