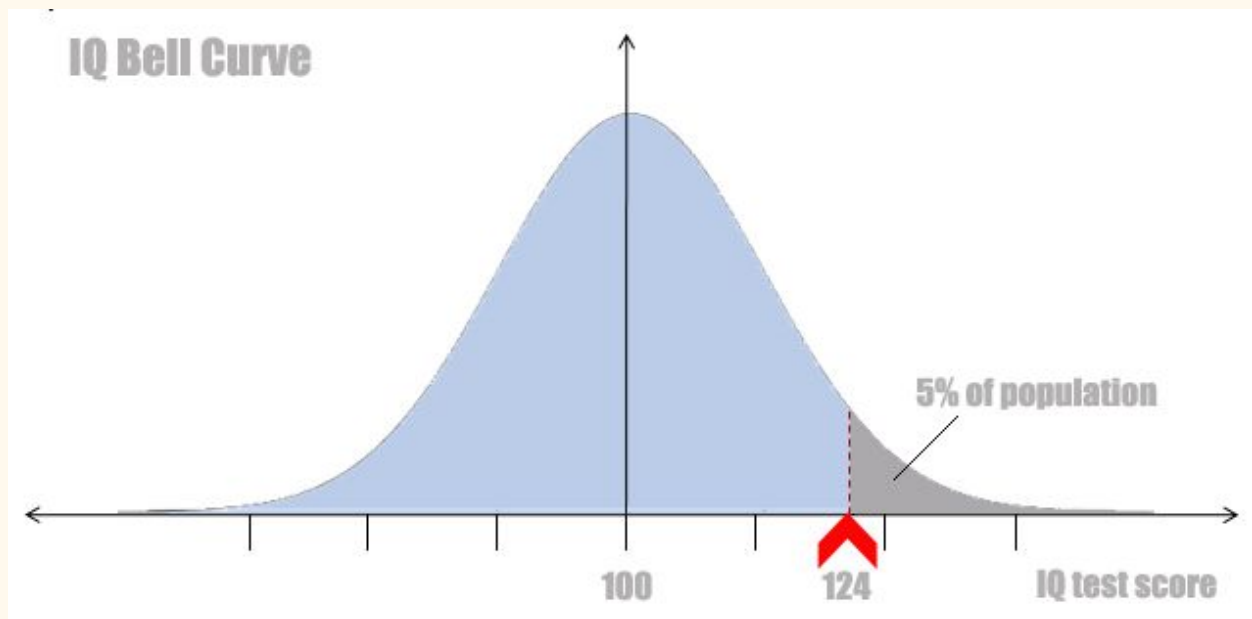


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PSYCHOMETRIC IQ AUGMENTATION 1



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WHAT IS GENERAL INTELLIGENCE?

Definitions

A good cognitive science definition of general intelligence is:

“... that facet of mind underlying our capacity to think, to solve novel problems, to reason and to have knowledge of the world.” M. Anderson

Note that the definition emphasizes **abstract** cognitive processes: thinking and reasoning and knowledge as mental models. This op-ed statement signed by fifty-two researchers in the field ([ref](#)) extends this idea to include learning and being ‘switched on’:

A very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience. It is not merely book learning, a narrow academic skill, or test-taking smarts. Rather, it reflects a broader and deeper capability for comprehending our surroundings — “catching on,” “making sense” of things, or “figuring out” what to do.

This 20+ year old definition still holds, but over the past 20 years different working definitions have evolved in different fields.

From an **applied IQ** perspective comes an emphasis on productivity, captured by:

“An intelligence is the ability to solve problems, or to create products, that are valued within one or more cultural settings.” **H. Gardner**

“. . . I prefer to refer to it as ‘successful intelligence.’ And the reason is that the emphasis is on the use of your intelligence to achieve success in your life. So I define it as your skill in achieving whatever it is you want to attain in your life within your sociocultural context” **R. Sternberg**

From the **artificial intelligence (AI)** movement comes an emphasis on efficient **goal** achievement, captured in these definitions:

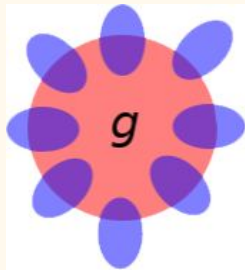
“Achieving complex goals in complex environments.” **B. Goertzel**

“Intelligence is the ability to use optimally limited resources – including time – to achieve goals.” **R. Kurzweil**

However intelligence is defined in real-life settings, from a scientific point of view, it needs to be **measured**, and the science of measuring cognitive abilities is called ‘psychometrics’.

It is the psychometric tradition that gives us our much-loved IQ tests such as the WISC-IV, WJ-IV and WAIS-IV, and the host of aptitude and ability tests that play an important selecting and streaming role in educational and professional development.

Psychometric IQ



Our numeric IQ level is what psychometric IQ tests measure. While people have different cognitive strengths and weaknesses (e.g. language, math, visuospatial), **correlations** (statistical links) between measures of these abilities show us there is a common component to all of them. This underlying component is called **g** (general intelligence). Standardized **full-scale** IQ tests are designed to measure *g*.

Further statistical analysis shows that test scores on different types of cognitive ability tests tend to cluster or group in certain ways, revealing a number of underlying ‘broad ability’ factors of intelligence - such as quantitative and general knowledge abilities.

Individuals can differ not just on how they score compared to others on their overall intelligence (*g*) but also on different broad abilities which we’ll look at below.

Individual Differences in Test Scores

“Each mind has its own method.” Emerson

“Minds differ more than faces.” Voltaire

As argued by the Director of the Institute for Applied Psychometrics, [Kevin McGrew](#), a major purpose of psychometric testing: to appreciate *the individual difference terrain or landscape of each individual’s personal abilities*. In other words, to understand each person’s **unique personal profile** - their cognitive peaks (potentialis, capacities, strengths) and valleys (weaknesses, deficiencies), to design programs to allow them to reach their fullest potential.

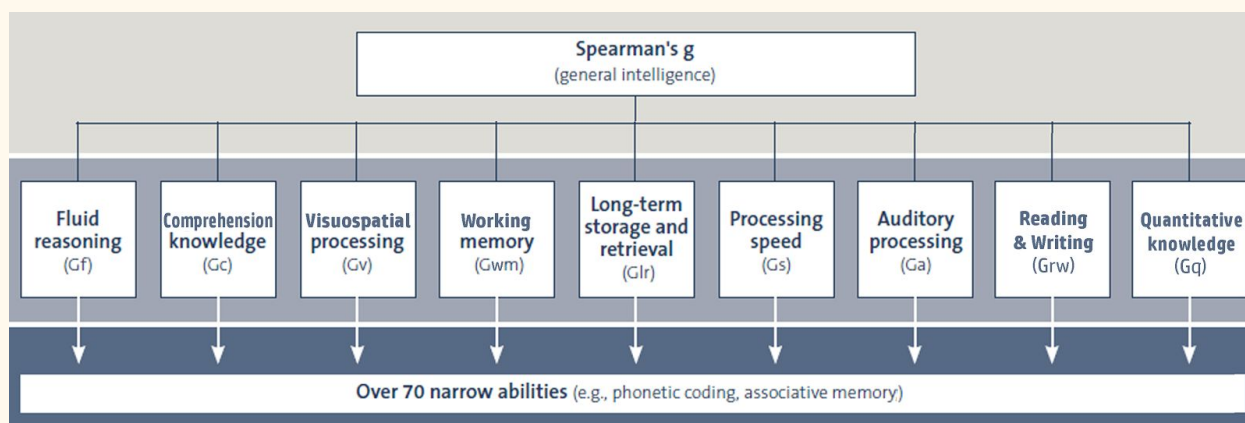
This is the primary aim underlying the development of IQ increasing apps such as [i3 Mindware](#).

Another purpose of psychological testing is **selection and streaming** - for example testing for college admissions or job selection.

The CHC Theory of General Intelligence (*g*)

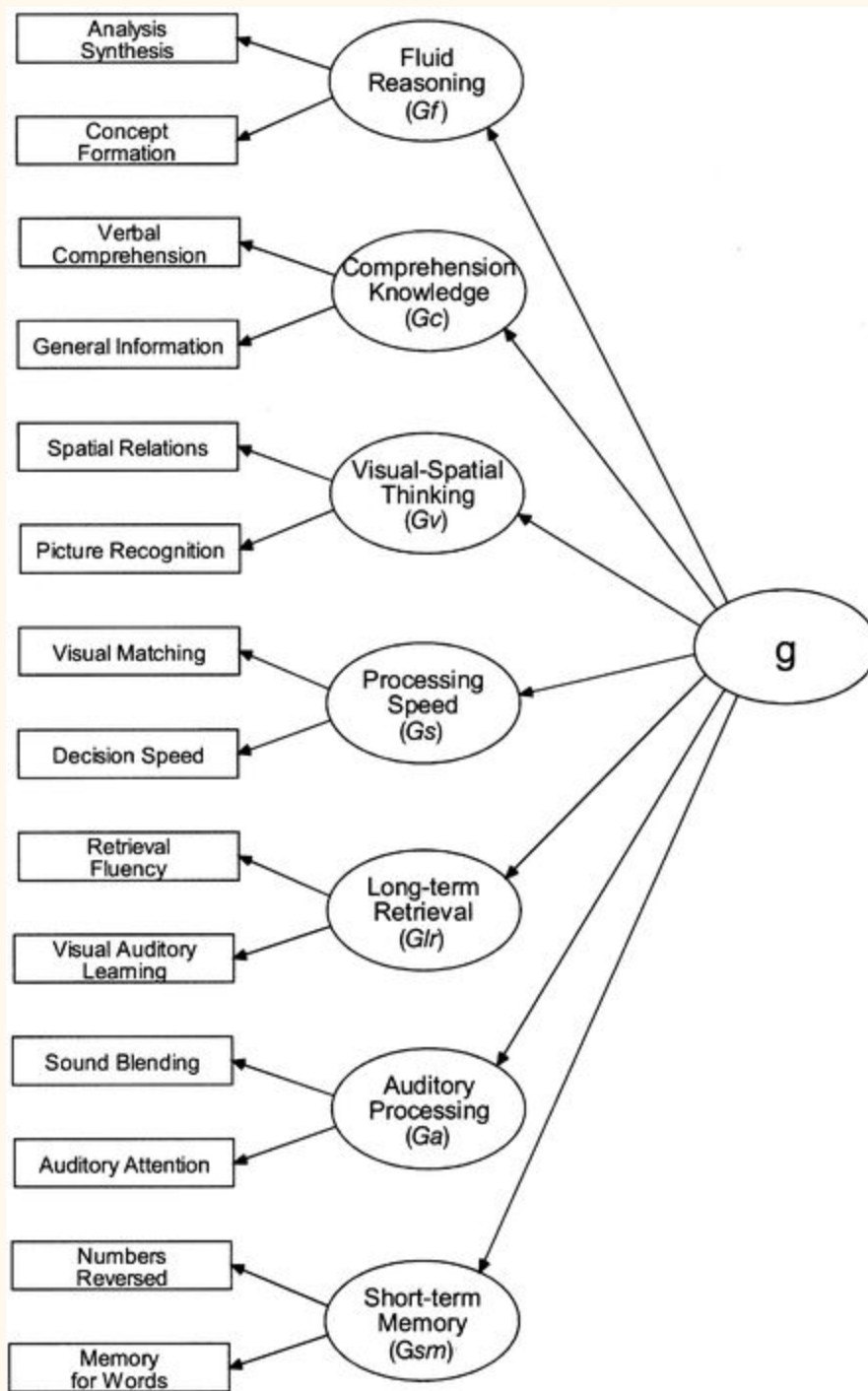
The CHC theory of intelligence ([ref](#)) is based on the analysis of hundreds of data-sets and is the most widely accepted taxonomy (classification) for intelligence..

There are **three strata** or levels. General intelligence (*Spearman's g* or simply *g*) is at the top (Stratum 3), with **9 broad ability domains** below that (Stratum 2), and more than 70 'narrow' abilities (Stratum 1) below that.



Individual differences in overall intelligence (*g*) as well as broad ability domains are measured by the IQ subtests full-scale, **professionally administered IQ tests** such as the WISC-V or WJ-IV.

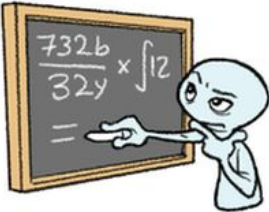


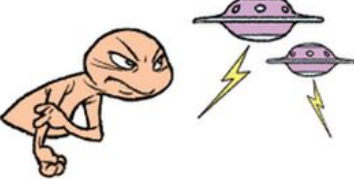


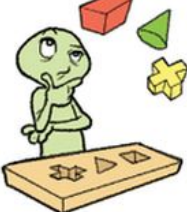


Here is a diagram showing how the broad ability domains of intelligence have been measured by subtests of the WJ-III IQ test (the subtest titles are on the left).



g, broad abilities, and their IQ subtests

So what *are* these broad cognitive abilities underlying our general intelligence?

All 9 are defined in this cartoon, taken from [Ungifted: Intelligence Redefined](#) by Scott Kaufman. Note that the label 'working memory (Gwm)' is now preferred to 'short-term memory' (Gsm) ([ref](#)).

<p>QUANTITATIVE KNOWLEDGE (GQ):</p>  <p>DEPTH AND BREADTH OF KNOWLEDGE RELATED TO MATHEMATICS.</p>	<p>READING + WRITING (GRW):</p>  <p>DEPTH AND BREADTH OF KNOWLEDGE AND SKILLS RELATED TO WRITTEN LANGUAGE.</p>	<p>COMPREHENSION - KNOWLEDGE (GC):</p>  <p>DEPTH AND BREADTH OF KNOWLEDGE AND SKILLS THAT ARE VALUED BY ONE'S CULTURE.</p>
<p>FLUID REASONING (GF):</p>  <p>THE DELIBERATE BUT FLEXIBLE CONTROL OF ATTENTION TO SOLVE NOVEL "ON THE SPOT" PROBLEMS THAT CANNOT BE PERFORMED BY RELYING EXCLUSIVELY ON PREVIOUSLY LEARNED HABITS, SCHEMAS, AND SCRIPTS.</p>	<p>SHORT-TERM MEMORY (GSM):</p>  <p>THE ABILITY TO ENCODE, MAINTAIN, AND MANIPULATE INFORMATION IN ONE'S IMMEDIATE AWARENESS.</p>	<p>LONG-TERM STORAGE + RETRIEVAL (GLR):</p>  <p>THE ABILITY TO STORE, CONSOLIDATE, AND RETRIEVE INFORMATION OVER PERIODS OF TIME MEASURED IN MINUTES, HOURS, DAYS, AND YEARS.</p>
<p>VISUAL PROCESSING (GV):</p>  <p>THE ABILITY TO MAKE USE OF SIMULATED MENTAL IMAGERY (OFTEN IN CONJUNCTION WITH CURRENTLY PERCEIVED IMAGES) TO SOLVE PROBLEMS.</p>	<p>AUDITORY PROCESSING (GA):</p>  <p>THE ABILITY TO DETECT AND PROCESS MEANINGFUL NONVERBAL INFORMATION IN SOUND.</p>	<p>PROCESSING SPEED (GS):</p>  <p>THE ABILITY TO PERFORM SIMPLE REPETITIVE COGNITIVE TASKS QUICKLY AND FLUENTLY.</p>

Broad Abilities Assessed in IQ Tests

Typically 5-7 of the broad abilities are measured by **sub-tests** in full-scale IQ tests such as the WJ-IV. For instance, the Spatial Relations and Picture Recognition subtests of the WJ-IV are measures of Visuospatial Processing (*Gv*) while the Concept Formation and Analysis-Synthesis subtests are measures of Fluid Reasoning (*Gf*).

The broad abilities of the CHC model often measured by subtests of full scale IQ tests are the following:

Comprehension Knowledge (*Gc*)

Also called 'Crystallized Intelligence'. This is knowledge and skills gained through experience, education and training. It depends on what we learn from our surrounding culture, and may be tested by vocabulary or general knowledge IQ subtests. Crystallized intelligence tends to remain constant over the lifespan and can even increase by acquiring more knowledge and skills.

Vocabulary-The examinee is asked to orally define words covering a wide range of difficulty. The test is designed to measure knowledge of words, which correlates with general mental ability.

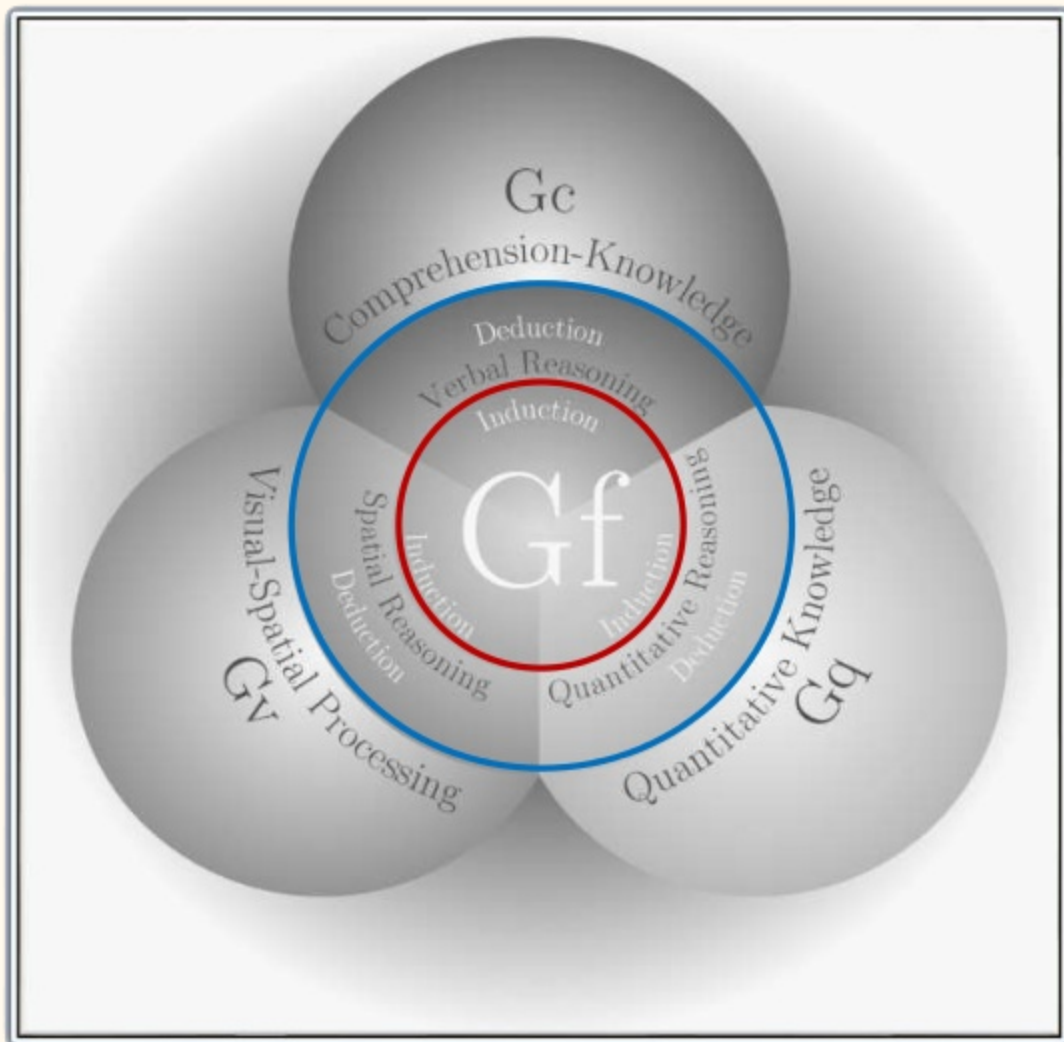
1. What does *retain* mean?
2. What does *robust* mean?
3. What does *sojourn* mean?
4. What does *harass* mean?
5. What does *desultory* mean?
6. What does *inclement* mean?

Gc IQ subtest questions

Fluid Reasoning (*Gf*)

Also called fluid intelligence, this is our on-the-spot reasoning and problem solving ability, not dependent on background knowledge, education or any specific expertise. It enables us to see relationships and learn quickly in new situations.

Fluid reasoning overlaps with other broad abilities as shown below ([ref](#)). *Gf* is the broad ability most closely associated with general intelligence (*g*).



Inductive (e.g. matrices) and deductive reasoning (logic) tests give us measures of *Gf* in IQ. Concept formation and analogical reasoning tests can also be used as measures of *Gf*.

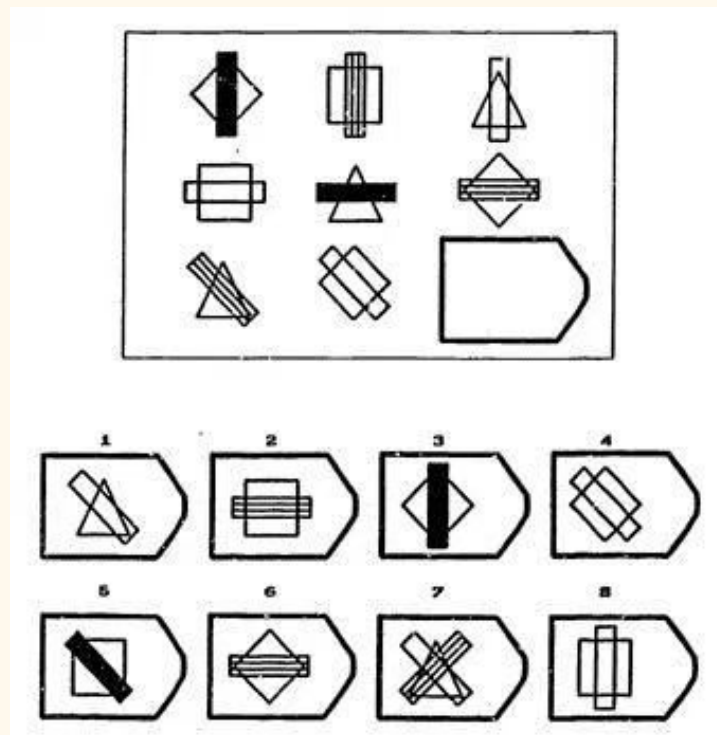
Similarities-Presents two words that represent common objects or concepts. The examinee is asked to state how the objects or concepts are similar. The task is designed to measure logical or abstract thinking and the ability to categorize and generalize.

In what way are a lion and a tiger alike?

In what way are a saw and a hammer alike?

In what way are an hour and a week alike?

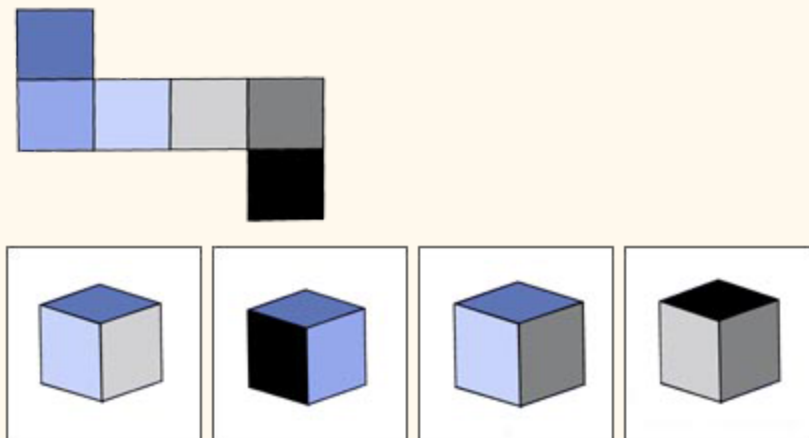
In what way are a circle and a triangle alike?



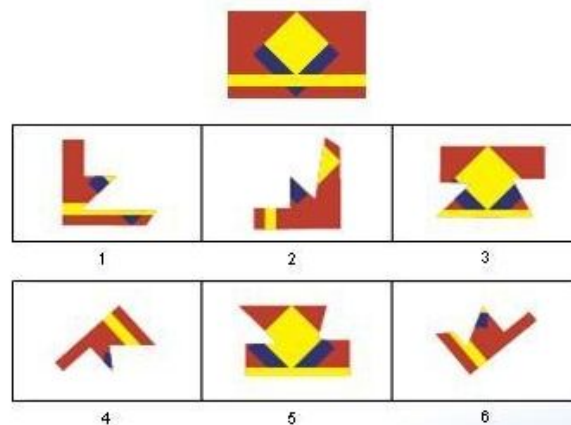
GfIQ subtest question

Visuospatial processing (*Gv*)

Visual processing or visual-spatial intelligence (*Gv*) involves the ability to visualize, remember and manipulate images or shapes in the 'mind's eye'. This kind of intelligence is measured by tasks where you need to mentally simulate how complex patterns might look when transformed (visualisation) or remembering complex patterns over short periods of time (visual memory).



“Which 3 of these pieces go together to make this puzzle?”



Gv IQ subtest questions

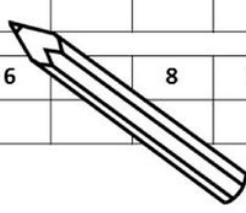
Processing speed (*Gs*)

Processing speed (*Gs*) is attention-focused speediness – your ability to automatically and fluently perform basic cognitive tasks (such as scanning or key pressing) that do not require much thinking - but still require concentration. This is measured by IQ sub-tests such as digit symbol matching (see below).

Digit:	1	2	3	4	5	6	7	8	9
Symbol:	—	⊥	⊏	└	┘	○	△	×	=

Samples					Test								
2	5	7	1	2	1	2	9	7	3	5	4		
⊥	┘	△	—	⊥									
1	4	3	5	9	6		8	1	2	4	2		

...



Gv IQ subtest question

Working Memory (*Gwm*)

Also referred to in the CHC theory as Short Term Memory (*Gsm*). This is a ‘**mental workspace**’ memory system that holds in current awareness information needed to problem solve, comprehend, reason, make decisions and so on. Unlike the unbounded long term memory, this is a **limited capacity** system that loses information quickly if it is not maintained in goal-directed cognition. It is measured by subtests such as memory span - both forwards and reversed.

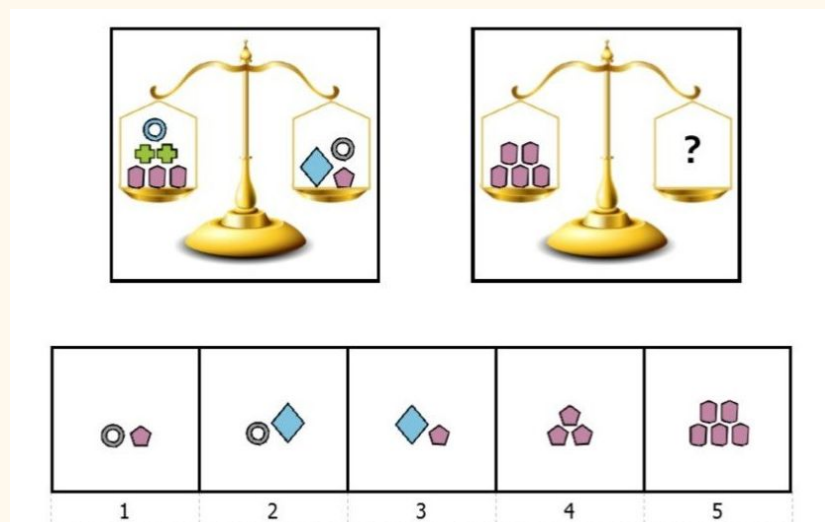
designed to measure attention span and working memory, which holds information in storage temporarily.

Digits forward	Correct response
3-9	3-9
4-2-6	4-2-6
7-1-8-7	7-1-8-7
5-8-2-3-9	5-8-2-3-9
Digits backward	Correct response
4-7	7-4
3-9-1	1-9-3
2-1-4-6	6-4-1-2
8-5-6-3-1	1-3-6-5-8

Gwm IQ subtest question

Quantitative Knowledge (*Gq*)

Quantitative knowledge (*Gq*) is mostly built up during formal educational experiences. *Gq* is a person's store of acquired mathematical knowledge and well practiced techniques for solving mathematical and quantitative problems. An example subtest for *Gq* is Figure-Weights.

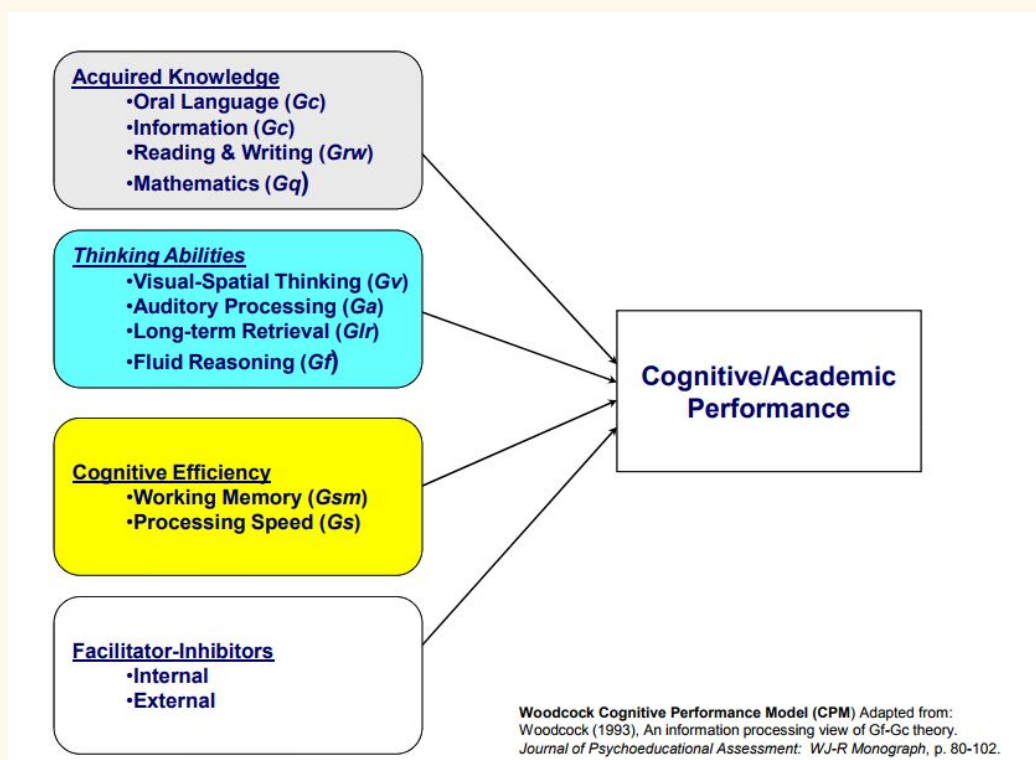


Gq IQ subtest question

The Cognitive Performance Model

The Cognitive Performance Model was developed by Richard Woodcock, one of the developers of the Woodcock Johnson IQ test (e.g. WJ-IV) ([ref](#)). It provides a more meaningful way of understanding the CHC theory of intelligence.

The broad abilities of intelligence are organized into three *information processing systems*: (1) stores of **Acquired Knowledge**, (2) **Thinking Abilities**, and (3) **Cognitive Efficiency** ([ref](#)). An interaction of all three of these, as well as facilitators such as motivation level or inhibitors such as lack of sleep, determine cognitive performance (*g*).



The Cognitive Performance Model

Acquired Knowledge (*Gc, Grw, Gq*)

This includes general knowledge, spoken language ability, math skills, reading and writing skills. The quality of learning and performance is dependent on the relevant

knowledge a person has. Knowledge is like scaffolding. Once information is learned, it can become a basis for new learning; missing information or knowledge can obviously impede future learning. Instruction strategies and opportunities for enrichment can affect a person's level of performance in this system.

All cognitive performance, whether automatic skills or new learning, is constrained by the store of knowledge that is available to you.

Thinking Abilities (*Gf, Gv, Ga, Glr*)

The thinking ability includes the ability to abstract ideas, to solve new problems, to process visual and auditory stimuli and to learn and to retrieve information from long term memory.

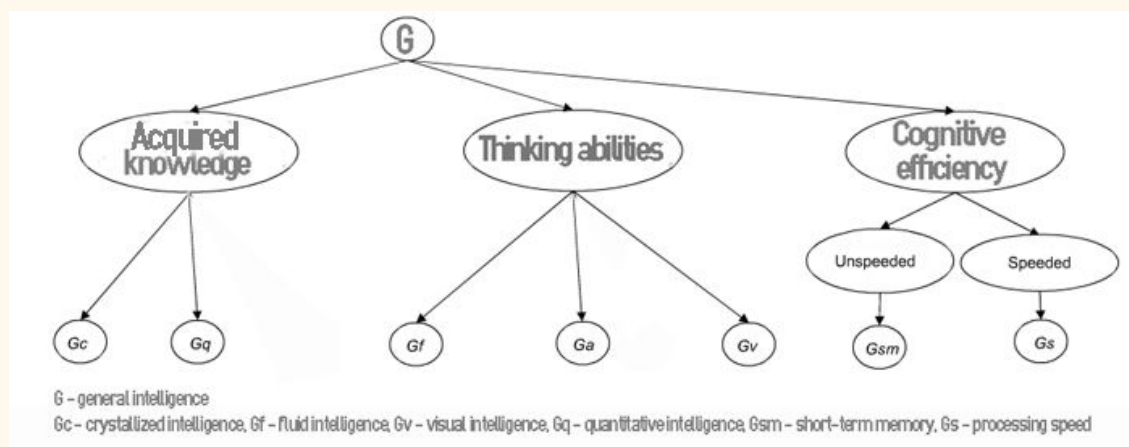
Cognitive Efficiency (*Gwm, Gs*)

The cognitive efficiency system includes the capacity of working memory (our mental workspace) as well as processing speed (our ability to perform a task quickly and with attentional focus). Expert performance is constrained by working memory and processing speed.

Facilitators-Inhibitors

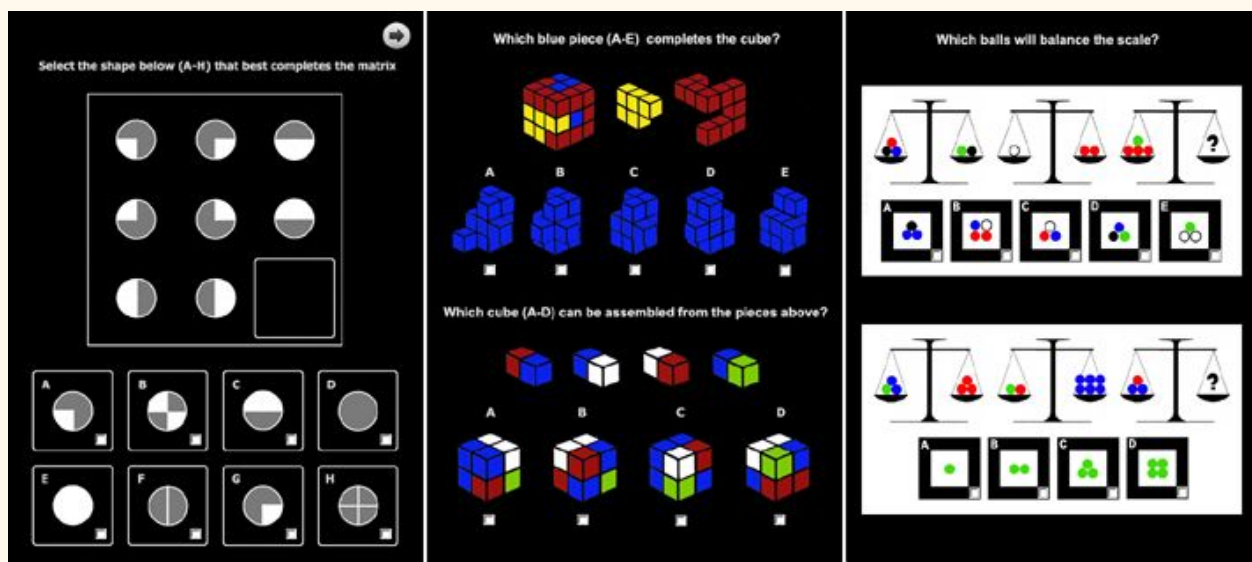
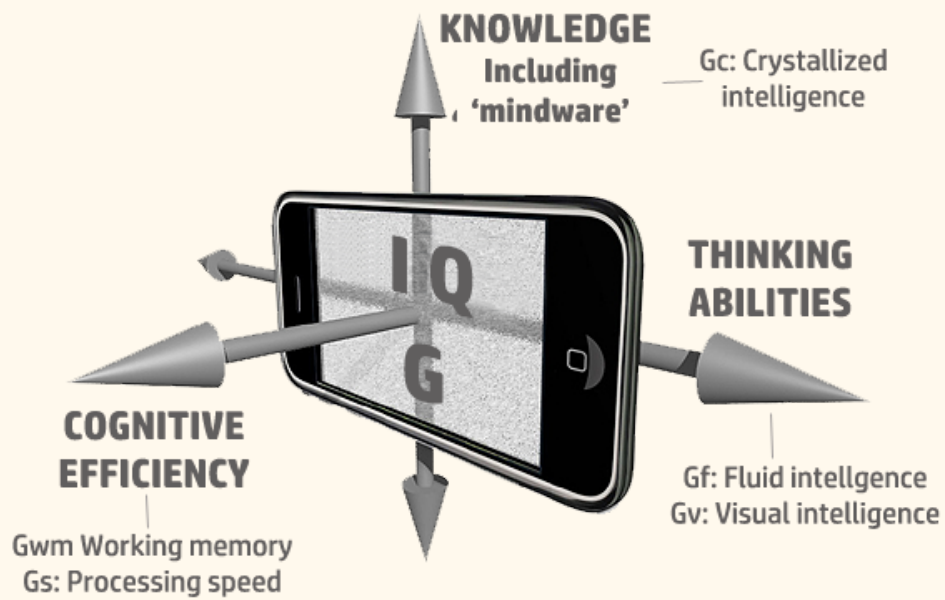
Internal- e.g. health, emotional state, personality & motivation. F

External - e.g. external distractions, the unique IQ test taken, time constraints.



The Cognitive Performance Model with 7 Broad Abilities

The Cognitive Performance Model is the basis for the design of the scientific [i3 Mindware app](#) for IQ augmentation.



Example IQ subtest problems for Gf, Gv and Gq in the i3 Mindware app