

# Logical Intelligence

Theory of multiple intelligences

*logical-mathematical, musical, and spatial intelligences. Introduced in Howard Gardner's book Frames of Mind: The Theory of Multiple Intelligences (1983)*

The theory of multiple intelligences (MI) posits that human intelligence is not a single general ability but comprises various distinct modalities, such as linguistic, logical-mathematical, musical, and spatial intelligences. Introduced in Howard Gardner's book *Frames of Mind: The Theory of Multiple Intelligences* (1983), this framework has gained popularity among educators who accordingly develop varied teaching strategies purported to cater to different student strengths.

Despite its educational impact, MI has faced criticism from the psychological and scientific communities. A primary point of contention is Gardner's use of the term "intelligences" to describe these modalities. Critics argue that labeling these abilities as separate intelligences expands the definition of intelligence beyond its traditional scope, leading to debates over its scientific validity.

While empirical research often supports a general intelligence factor (g-factor), Gardner contends that his model offers a more nuanced understanding of human cognitive abilities. This difference in defining and interpreting "intelligence" has fueled ongoing discussions about the theory's scientific robustness.

Artificial intelligence

*solving word problems in algebra, proving logical theorems and speaking English. Artificial intelligence laboratories were set up at a number of British*

Artificial intelligence (AI) is the capability of computational systems to perform tasks typically associated with human intelligence, such as learning, reasoning, problem-solving, perception, and decision-making. It is a field of research in computer science that develops and studies methods and software that enable machines to perceive their environment and use learning and intelligence to take actions that maximize their chances of achieving defined goals.

High-profile applications of AI include advanced web search engines (e.g., Google Search); recommendation systems (used by YouTube, Amazon, and Netflix); virtual assistants (e.g., Google Assistant, Siri, and Alexa); autonomous vehicles (e.g., Waymo); generative and creative tools (e.g., language models and AI art); and superhuman play and analysis in strategy games (e.g., chess and Go). However, many AI applications are not perceived as AI: "A lot of cutting edge AI has filtered into general applications, often without being called AI because once something becomes useful enough and common enough it's not labeled AI anymore."

Various subfields of AI research are centered around particular goals and the use of particular tools. The traditional goals of AI research include learning, reasoning, knowledge representation, planning, natural language processing, perception, and support for robotics. To reach these goals, AI researchers have adapted and integrated a wide range of techniques, including search and mathematical optimization, formal logic, artificial neural networks, and methods based on statistics, operations research, and economics. AI also draws upon psychology, linguistics, philosophy, neuroscience, and other fields. Some companies, such as OpenAI, Google DeepMind and Meta, aim to create artificial general intelligence (AGI)—AI that can complete virtually any cognitive task at least as well as a human.

Artificial intelligence was founded as an academic discipline in 1956, and the field went through multiple cycles of optimism throughout its history, followed by periods of disappointment and loss of funding, known

as AI winters. Funding and interest vastly increased after 2012 when graphics processing units started being used to accelerate neural networks and deep learning outperformed previous AI techniques. This growth accelerated further after 2017 with the transformer architecture. In the 2020s, an ongoing period of rapid progress in advanced generative AI became known as the AI boom. Generative AI's ability to create and modify content has led to several unintended consequences and harms, which has raised ethical concerns about AI's long-term effects and potential existential risks, prompting discussions about regulatory policies to ensure the safety and benefits of the technology.

## Logical reasoning

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Logical reasoning is a mental activity that aims to arrive at a conclusion in a rigorous way. It happens in the form of inferences or arguments by starting from a set of premises and reasoning to a conclusion supported by these premises. The premises and the conclusion are propositions, i.e. true or false claims about what is the case. Together, they form an argument. Logical reasoning is norm-governed in the sense that it aims to formulate correct arguments that any rational person would find convincing. The main discipline studying logical reasoning is logic.

Distinct types of logical reasoning differ from each other concerning the norms they employ and the certainty of the conclusion they arrive at. Deductive reasoning offers the strongest support: the premises ensure the conclusion, meaning that it is impossible for the conclusion to be false if all the premises are true. Such an argument is called a valid argument, for example: all men are mortal; Socrates is a man; therefore, Socrates is mortal. For valid arguments, it is not important whether the premises are actually true but only that, if they were true, the conclusion could not be false. Valid arguments follow a rule of inference, such as modus ponens or modus tollens. Deductive reasoning plays a central role in formal logic and mathematics.

For non-deductive logical reasoning, the premises make their conclusion rationally convincing without ensuring its truth. This is often understood in terms of probability: the premises make it more likely that the conclusion is true and strong inferences make it very likely. Some uncertainty remains because the conclusion introduces new information not already found in the premises. Non-deductive reasoning plays a central role in everyday life and in most sciences. Often-discussed types are inductive, abductive, and analogical reasoning. Inductive reasoning is a form of generalization that infers a universal law from a pattern found in many individual cases. It can be used to conclude that "all ravens are black" based on many individual observations of black ravens. Abductive reasoning, also known as "inference to the best explanation", starts from an observation and reasons to the fact explaining this observation. An example is a doctor who examines the symptoms of their patient to make a diagnosis of the underlying cause. Analogical reasoning compares two similar systems. It observes that one of them has a feature and concludes that the other one also has this feature.

Arguments that fall short of the standards of logical reasoning are called fallacies. For formal fallacies, like affirming the consequent, the error lies in the logical form of the argument. For informal fallacies, like false dilemmas, the source of the faulty reasoning is usually found in the content or the context of the argument. Some theorists understand logical reasoning in a wide sense that is roughly equivalent to critical thinking. In this regard, it encompasses cognitive skills besides the ability to draw conclusions from premises. Examples are skills to generate and evaluate reasons and to assess the reliability of information. Further factors are to seek new information, to avoid inconsistencies, and to consider the advantages and disadvantages of different courses of action before making a decision.

## Intelligence quotient

Gottfredson, Linda S. (2009). *"Chapter 1: Logical Fallacies Used to Dismiss the Evidence on Intelligence Testing"*. In Phelps, Richard F. (ed.). *Correcting*

An intelligence quotient (IQ) is a total score derived from a set of standardized tests or subtests designed to assess human intelligence. Originally, IQ was a score obtained by dividing a person's estimated mental age, obtained by administering an intelligence test, by the person's chronological age. The resulting fraction (quotient) was multiplied by 100 to obtain the IQ score. For modern IQ tests, the raw score is transformed to a normal distribution with mean 100 and standard deviation 15. This results in approximately two-thirds of the population scoring between IQ 85 and IQ 115 and about 2 percent each above 130 and below 70.

Scores from intelligence tests are estimates of intelligence. Unlike quantities such as distance and mass, a concrete measure of intelligence cannot be achieved given the abstract nature of the concept of "intelligence". IQ scores have been shown to be associated with such factors as nutrition, parental socioeconomic status, morbidity and mortality, parental social status, and perinatal environment. While the heritability of IQ has been studied for nearly a century, there is still debate over the significance of heritability estimates and the mechanisms of inheritance. The best estimates for heritability range from 40 to 60% of the variance between individuals in IQ being explained by genetics.

IQ scores were used for educational placement, assessment of intellectual ability, and evaluating job applicants. In research contexts, they have been studied as predictors of job performance and income. They are also used to study distributions of psychometric intelligence in populations and the correlations between it and other variables. Raw scores on IQ tests for many populations have been rising at an average rate of three IQ points per decade since the early 20th century, a phenomenon called the Flynn effect. Investigation of different patterns of increases in subtest scores can also inform research on human intelligence.

Historically, many proponents of IQ testing have been eugenicists who used pseudoscience to push later debunked views of racial hierarchy in order to justify segregation and oppose immigration. Such views have been rejected by a strong consensus of mainstream science, though fringe figures continue to promote them in pseudo-scholarship and popular culture.

## Inference

*Inferences are steps in logical reasoning, moving from premises to logical consequences; etymologically, the word infer means to "carry forward";. Inference*

Inferences are steps in logical reasoning, moving from premises to logical consequences; etymologically, the word infer means to "carry forward". Inference is theoretically traditionally divided into deduction and induction, a distinction that in Europe dates at least to Aristotle (300s BC). Deduction is inference deriving logical conclusions from premises known or assumed to be true, with the laws of valid inference being studied in logic. Induction is inference from particular evidence to a universal conclusion. A third type of inference is sometimes distinguished, notably by Charles Sanders Peirce, contradistinguishing abduction from induction.

Various fields study how inference is done in practice. Human inference (i.e. how humans draw conclusions) is traditionally studied within the fields of logic, argumentation studies, and cognitive psychology; artificial intelligence researchers develop automated inference systems to emulate human inference. Statistical inference uses mathematics to draw conclusions in the presence of uncertainty. This generalizes deterministic reasoning, with the absence of uncertainty as a special case. Statistical inference uses quantitative or qualitative (categorical) data which may be subject to random variations.

## Automated reasoning

*itself led to the development of artificial intelligence. A formal proof is a proof in which every logical inference has been checked back to the fundamental*

In computer science, in particular in knowledge representation and reasoning and metalogic, the area of automated reasoning is dedicated to understanding different aspects of reasoning. The study of automated reasoning helps produce computer programs that allow computers to reason completely, or nearly completely, automatically. Although automated reasoning is considered a sub-field of artificial intelligence, it also has connections with theoretical computer science and philosophy.

The most developed subareas of automated reasoning are automated theorem proving (and the less automated but more pragmatic subfield of interactive theorem proving) and automated proof checking (viewed as guaranteed correct reasoning under fixed assumptions). Extensive work has also been done in reasoning by analogy using induction and abduction.

Other important topics include reasoning under uncertainty and non-monotonic reasoning. An important part of the uncertainty field is that of argumentation, where further constraints of minimality and consistency are applied on top of the more standard automated deduction. John Pollock's OSCAR system is an example of an automated argumentation system that is more specific than being just an automated theorem prover.

Tools and techniques of automated reasoning include the classical logics and calculi, fuzzy logic, Bayesian inference, reasoning with maximal entropy and many less formal ad hoc techniques.

In the 2020s, to enhance the ability of large language models to solve complex problems, AI researchers have designed reasoning language models that can spend additional time on the problem before generating an answer.

### A Logical Calculus of the Ideas Immanent in Nervous Activity

*perform all logical functions. It is a seminal work in cognitive science, computational neuroscience, computer science, and artificial intelligence. It was*

"A Logical Calculus of the Ideas Immanent in Nervous Activity" is a 1943 article written by Warren McCulloch and Walter Pitts. The paper, published in the journal *The Bulletin of Mathematical Biophysics*, proposed a mathematical model of the nervous system as a network of simple logical elements, later known as artificial neurons, or McCulloch-Pitts neurons. These neurons receive inputs, perform a weighted sum, and fire an output signal based on a threshold function. By connecting these units in various configurations, McCulloch and Pitts demonstrated that their model could perform all logical functions.

It is a seminal work in cognitive science, computational neuroscience, computer science, and artificial intelligence. It was a foundational result in automata theory. John von Neumann cited it as a significant result.

### Artificial general intelligence

*Artificial general intelligence (AGI)—sometimes called human-level intelligence AI—is a type of artificial intelligence that would match or surpass human*

Artificial general intelligence (AGI)—sometimes called human-level intelligence AI—is a type of artificial intelligence that would match or surpass human capabilities across virtually all cognitive tasks.

Some researchers argue that state-of-the-art large language models (LLMs) already exhibit signs of AGI-level capability, while others maintain that genuine AGI has not yet been achieved. Beyond AGI, artificial superintelligence (ASI) would outperform the best human abilities across every domain by a wide margin.

Unlike artificial narrow intelligence (ANI), whose competence is confined to well-defined tasks, an AGI system can generalise knowledge, transfer skills between domains, and solve novel problems without

task-specific reprogramming. The concept does not, in principle, require the system to be an autonomous agent; a static model—such as a highly capable large language model—or an embodied robot could both satisfy the definition so long as human-level breadth and proficiency are achieved.

Creating AGI is a primary goal of AI research and of companies such as OpenAI, Google, and Meta. A 2020 survey identified 72 active AGI research and development projects across 37 countries.

The timeline for achieving human-level intelligence AI remains deeply contested. Recent surveys of AI researchers give median forecasts ranging from the late 2020s to mid-century, while still recording significant numbers who expect arrival much sooner—or never at all. There is debate on the exact definition of AGI and regarding whether modern LLMs such as GPT-4 are early forms of emerging AGI. AGI is a common topic in science fiction and futures studies.

Contention exists over whether AGI represents an existential risk. Many AI experts have stated that mitigating the risk of human extinction posed by AGI should be a global priority. Others find the development of AGI to be in too remote a stage to present such a risk.

## History of artificial intelligence

*Artificial Intelligence*; *Defending AI Research: A Collection of Essays and Reviews*. CSLI. McCulloch WS, Pitts W (1 December 1943). *"A logical calculus*

The history of artificial intelligence (AI) began in antiquity, with myths, stories, and rumors of artificial beings endowed with intelligence or consciousness by master craftsmen. The study of logic and formal reasoning from antiquity to the present led directly to the invention of the programmable digital computer in the 1940s, a machine based on abstract mathematical reasoning. This device and the ideas behind it inspired scientists to begin discussing the possibility of building an electronic brain.

The field of AI research was founded at a workshop held on the campus of Dartmouth College in 1956. Attendees of the workshop became the leaders of AI research for decades. Many of them predicted that machines as intelligent as humans would exist within a generation. The U.S. government provided millions of dollars with the hope of making this vision come true.

Eventually, it became obvious that researchers had grossly underestimated the difficulty of this feat. In 1974, criticism from James Lighthill and pressure from the U.S.A. Congress led the U.S. and British Governments to stop funding undirected research into artificial intelligence. Seven years later, a visionary initiative by the Japanese Government and the success of expert systems reinvigorated investment in AI, and by the late 1980s, the industry had grown into a billion-dollar enterprise. However, investors' enthusiasm waned in the 1990s, and the field was criticized in the press and avoided by industry (a period known as an "AI winter"). Nevertheless, research and funding continued to grow under other names.

In the early 2000s, machine learning was applied to a wide range of problems in academia and industry. The success was due to the availability of powerful computer hardware, the collection of immense data sets, and the application of solid mathematical methods. Soon after, deep learning proved to be a breakthrough technology, eclipsing all other methods. The transformer architecture debuted in 2017 and was used to produce impressive generative AI applications, amongst other use cases.

Investment in AI boomed in the 2020s. The recent AI boom, initiated by the development of transformer architecture, led to the rapid scaling and public releases of large language models (LLMs) like ChatGPT. These models exhibit human-like traits of knowledge, attention, and creativity, and have been integrated into various sectors, fueling exponential investment in AI. However, concerns about the potential risks and ethical implications of advanced AI have also emerged, causing debate about the future of AI and its impact on society.

## Human intelligence

*intelligence down into components. In the first edition of his book *Frames of Mind* (1983), he described seven distinct types of intelligence: logical-mathematical*

Human intelligence is the intellectual capability of humans, which is marked by complex cognitive feats and high levels of motivation and self-awareness. Using their intelligence, humans are able to learn, form concepts, understand, and apply logic and reason. Human intelligence is also thought to encompass their capacities to recognize patterns, plan, innovate, solve problems, make decisions, retain information, and use language to communicate.

There are conflicting ideas about how intelligence should be conceptualized and measured. In psychometrics, human intelligence is commonly assessed by intelligence quotient (IQ) tests, although the validity of these tests is disputed. Several subcategories of intelligence, such as emotional intelligence and social intelligence, have been proposed, and there remains significant debate as to whether these represent distinct forms of intelligence.

There is also ongoing debate regarding how an individual's level of intelligence is formed, ranging from the idea that intelligence is fixed at birth to the idea that it is malleable and can change depending on a person's mindset and efforts.

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