Sustainable Energy and AI Technologies

Academixs Open Access Publishers

Review Article

Computers and the Demonstration of Cognitive Competencies?

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Received Date: 26.04.2026 **Accepted Date:** 01.05.2026 **Published Date:** 09.05.2026

Abstract

Cognition is the mental process of acquiring knowledge and understanding through thought, experience, and senses. Cognitive processes start with thinking and knowing and go all the way to remembering, judging, and problem-solving. They involve higher-level functions of the brain such as language, imagination, perception, and planning. Basic cognitive processes of perception, attention, and memory could lead to creativity.

Could integrated circuits and derived software that we call computers ever acquire and demonstrate cognitive competencies? This is the focus of the following article.

The article starts with a definition of cognitive competencies. It explores their parameters and prime functions. It then proceeds to explore what we may refer to as the competencies of the computer or the amalgam of integrated circuits and their software capabilities. A comparison follows and gaps, overlaps and loopholes are identified.
The article relies on works on neurology, electronics, data science and psychology.
Analysis is qualitative.

I. What is a computer?

A computer is a device that could be programmed. It stores, retrieves, and processes data. ("What is a computer?") It is an electronic device that resorts to integrated circuits. It receives and processes data and produce outputs to store within its boundaries. It can also be programmed to automatically carry out sequences of arithmetic or logical operations and perform generic sets of a variety of tasks. ("Computer - Wikipedia")

II. What is cognition?

There exists a variety of definitions for cognition, but they all boil down to being "the mental action or process of acquiring knowledge and understanding through thought, experience, and the senses". [1] Put differently it is the mental processes involved in gaining knowledge and comprehension. Cognitive processes include thinking, knowing, remembering, judging, and problem-solving. They involve higher-level functions of the brain such as language, imagination, perception, and planning.

Basic cognitive processes of perception, attention, and memory could lead to creativity. "Creative cognition involves perceptive original interpretation of experiences or associations with support from memory and stored information." ("Cognitive Predictions | SpringerLink") Creative cognition may also be metacognitive and tactical i.e. it allows the individual to exert a degree of control over his own thinking and direct individual cognition to the generation of original and useful ideas, insights, and solutions.

The prime cognitive functions of the brain

"Cognitive functions of the brain spread over a wide span with memory and perception at the forefront." ("Cognitive Predictions | SpringerLink") ("Cognitive Predictions | SpringerLink")

Memory

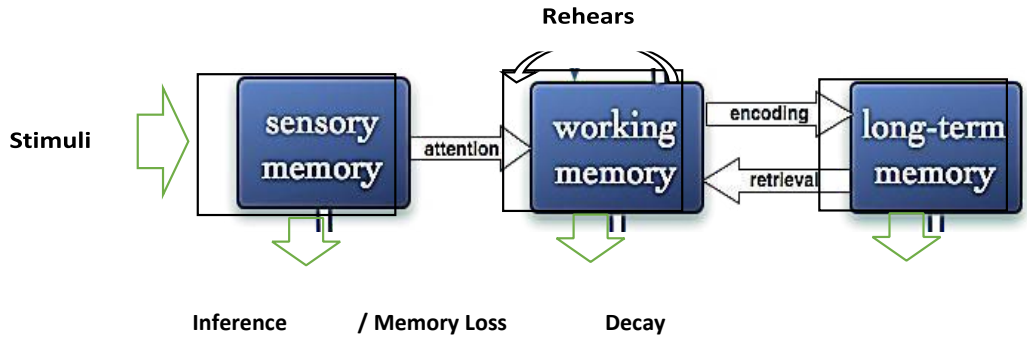
Memory is the process by which knowledge is encoded, stored, and retrieved. It could be short term or working memory or long term. Short-term memory and working memory terms are often used interchangeably. There are scholars who claim that some kind of manipulation of remembered information is needed to qualify the task as one of working memory. ("8 Reasons Why Working Memory Is Important - Edu lox Online Tutor") (Atkinson, 1968).

Senses are involved too. Visual memory involves the ability to store and retrieve previously experienced visual sensations and perceptions when the stimuli that originally evoked them, are no longer present. ("Visual memory involves the... - Edublox

Port Elizabeth - Facebook") ("Visual memory involves the... - Edublox Port Elizabeth - Facebook") Auditory memory, on the other hand, involves the skills of attending, listening, processing, storing, and recalling. Sequential memory requires items to be recalled in a specific order. Visual sequential memory is the ability to remember things seen in sequence, while auditory sequential memory is the ability to remember things heard in sequence. ("Sequential Memory: Definition, Importance, Overcoming Deficits")

Sensory memory is the shortest-term element of memory. It is the ability to retain impressions of sensory information after the original stimuli has ended. ("Sensory Memory | Types of Memory Facts & Information") ("Sensory Memory |. It acts as a kind of buffer for stimuli received through the five senses of sight, hearing, smell, taste and touch, which are retained accurately, [3].

Figure: Memory segments



Source: Adapted from Atkinson, R.C. and Shiffrin, R.M. (1968).

Perception

Sensation is the absorption of information by a sensory receptor Perception is the *interpretation* of what is sensed. Visual perception refers to the brain's ability to make sense of what the eyes see, while auditory perception is the ability to identify, interpret, and attach meaning to sound. Lack of experience may cause a person to misinterpret what he has seen or heard. In other words, perception represents our apprehension of the present situation in terms of our past experiences. "We see things not as they are but as we are." ("Quote Origin: We Don't See Things as They Are, We See Them as We Are")

Attention

Attention is the ability to actively process specific information in the environment to the exclusion of others. It is an ability to choose and concentrate on relevant stimuli. ("What is attention according to cognitive psychology?") Attention is a basic component of human biology. Orienting reflexes help determine which events in the environment need to be attended to, a vital process. ("Cognitive Predictions | SpringerLink") There are, however, different segments of attention. ("Cognitive Predictions | SpringerLink") One of those makes a distinction between arousal, focused, sustained, selective, alternating and divided attention. (Sohlberg and Mateer 1987, 1989). Another classifies attention as sustained, alternating, selective, focused and Limited Attention [5].

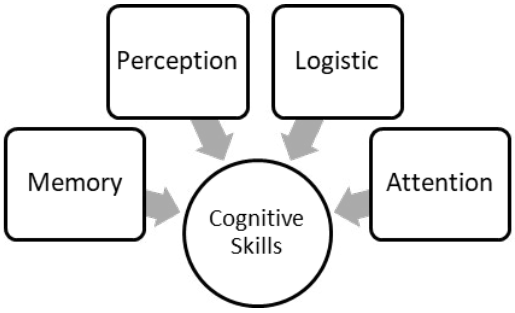
Perception and attention are related to each other by the outcome that an individual experiencing stimuli assigns his/her awareness to the object he/she identifies (Bayne & Montague, 2011).

Logical reasoning

"Logical reasoning is the process of using a rational, systematic series of steps based on sound mathematical procedures and given statements to arrive at a conclusion."
("Chapter Five - critical thinking - Chapter Five Logical ... - Studocu") ("Chapter Five" - critical thinking)

In logic, there are two broad methods of reaching a conclusion, deductive reasoning and inductive reasoning. Deduction begins with a major premise followed by a minor premise. In inductive reasoning broad conclusions are drawn from specific observations.
("Deductive vs Inductive Reasoning: Make Smarter Arguments, better ...")

Figure; Key elements of cognitive skills



Source: Susan du Plessis, 2018

The contrast: computers vs human brain.

“”Cognitive Technology is defined as technology that enables machines to possess mental abilities to mimic human behavior, learn from experiences, and make decisions, ultimately infusing intelligence into nonintelligent machines.” (“Cognitive Technology - an overview | ScienceDirect Topics”) “Cognitive Technology - an overview | ScienceDirect Topics”) Cognitive technologies, or ‘thinking’ technologies, fall within a broad category that includes algorithms, robotic process automation, machine learning, natural language processing and … (“What is cognitive technology? - ICAEW)

The following table provides a comparative analysis of the parameters of the human brain and the computing entity we call computers.

Table: Difference Between Brain and Computer

BASIS FOR COMPARISON	BRAIN	COMPUTER
Input/output equipment	Sensory organs	Keyboards, mouse, web cameras, etc.
Structural organization	Self-organized	Pre-programmed structure
Parallelism	Massive	Limited
Reliability and damageability properties	Brain is self-organizing, self-maintaining and reliable.	Computers perform a monotonous job and can't correct itself.

Source: 2025 · Tech Differences, Difference Between Brain and Computer

Which Cognitive Competencies Could Computers Simulate? And how?

• Memory

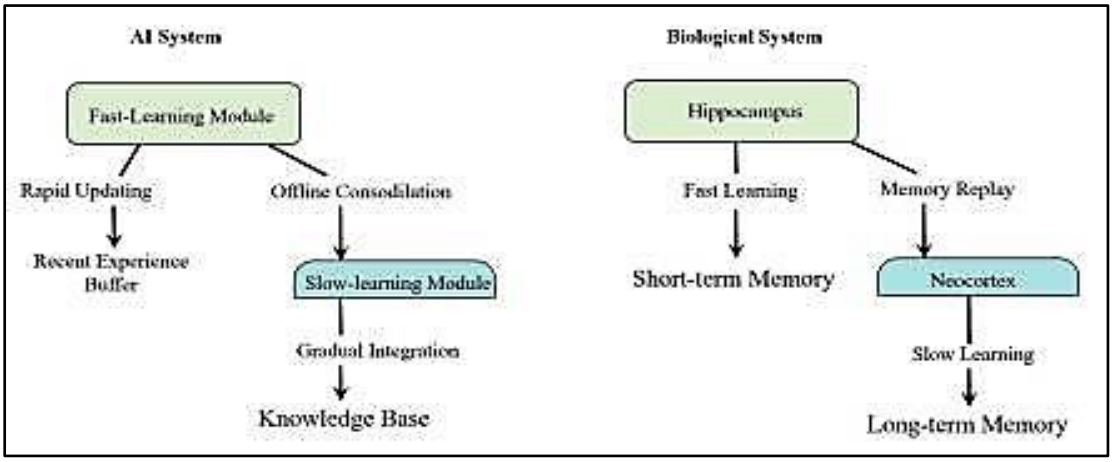
Learning memories seem to be beyond the capability of today’s computing equipment.

The quest to create artificial intelligence (AI) systems capable of continuous learning while maintaining previously acquired knowledge remains one of the serious challenges in machine learning. This challenge, known as the stability–plasticity dilemma, lies at the heart of developing AI systems that can adapt to added information without catastrophically forgetting past learning. (“Neuroplasticity Meets Artificial Intelligence: A Hippocampus-Inspired ...”)

Another critical challenge is what is referred to as “catastrophic forgetting,” which relates to the stability–plasticity dilemma. Catastrophic forgetting occurs when artificial neural networks rapidly overwrite previously acquired knowledge when exposed to new data or tasks. (“Neuroplasticity Meets Artificial Intelligence: A Hippocampus-Inspired ...”)

Recent advances in AI, such as deep reinforcement learning () and large language models () and deep seek (), demonstrate the potential for brain-inspired approaches. However, significant challenges remain in bridging the gap between biological and artificial neural networks ().

Figure AI vs biological systems.



Source: Rudroff T, Rainio O, Klén R. Neuroplasticity Meets Artificial Intelligence: Brain Sci. 2024 Oct.https://pmc.ncbi.nlm.nih.gov/articles/PMC11591613/

Attention

A deep learning model allows for a measure of attention by computing equipment.

This deep learning model allows for selective focus on specific areas of input data when making predictions. This mechanism allows the computer to pay a variable level of attention to specific data segments. ("What are Attention Mechanisms in Deep Learning?") It allows model thus to focus on what is most important for a given job.

This attention mechanism software has found applications in artificial intelligence in a wide range of domains including machine translation, natural language processing (NLP), computer vision and reinforcement learning. Attention computing aims thus at getting the most out of technology by ensuring everyone can interact with it and enabling machines to interpret human behaviour and predict what action to take.

Logic and perception

Computers use a measure of logic but can not reason.

Logic, by definition, is a system of manipulating symbols according to rules. Computers can manipulate symbols according to rules as well. They are designed to do so, and, in that sense, computers can use logic. ("Do computers use logic? - Philosophy Stack Exchange")

Computers, however, cannot reason. Reasoning involves several processes including valuation, goal setting, reflexive analysis, reversibility, error awareness, among others. "A computer can manipulate symbols to get from A to B easily enough, but it cannot (currently) distinguish A or B from each other or any other proposition, cannot evaluate the importance or value of this proposition, cannot decide to do that manipulation on its own." https://philosophy.stackexchange.com/questions/99276/do-computers-use-logic"

Computers, therefore, do not use logic as a cognitive competency. There is no thinking, and no consciousness. What there is, is immense data storage and analysis capabilities that allow the achievement of outstanding tasks beyond human performance parameters... ("Do computers use logic? - Philosophy Stack Exchange") ("Do computers use logic? - Philosophy Stack Exchange")

Case: Military Drones

Integration of the cognitive competency of environmental awareness in drones is a case in point.

Drone can navigate unknown lands without the need for GPS tracking, giving military troops the capability to collect data on pursual. Drones could allow operators to make decisions without being concerned with possible rear attack. ("Microsoft Word - 075.doc - ResearchGate") Combat drone technology is capable of being the most lethal and effective for intermediate and close combat scenarios.

Drone technology is new to the military, but its use is currently pervasive. They have improved military technology capabilities by relaying crucial information on enemy movements, locations, and positions of strategic targets. This ability creates the right environment for effective military decision making.

Drone software contains an element of environmental awareness, a cognitive competency. A deep learning neural network (Neurala) helps drones sift through crowds to find and identify persons of interest. ("AI-Powered Enhance Drones Saving Lives - Intercore Technologies") ("AI-Powered Enhance Drones Saving Lives - Intercore Technologies") This environmental awareness. The manufacturer claims that its AI powered software can identify individual in a crowd within 20 minutes.

Derived Hypotheses

Analysis done above could lead to several hypotheses that could guide future research.

• Cognitive competencies of computing equipment do only partly simulate some of the cognitive competencies of the human brain.

• Considerable advances in technology are needed before specific biological competencies of the human brain, as self-

awareness, are fully acquired by computing equipment.
• Advanced capabilities of computing equipment's can enhance the cognitive competencies of the computer.

Summary and Conclusions

Cognition is the mental process of acquiring knowledge and understanding through thought, experience, and senses. ("What is cognition? - Cambridge Cognition") ("What is cognition? - Cambridge Cognition") Cognitive processes start with thinking and knowing and go all the way to remembering, judging, and problem-solving. They involve higher-level functions of the brain such as language, imagination, perception, and planning. Basic cognitive processes of perception, attention, and memory could lead to creativity.

Could integrated circuits and derived software that we call computers ever acquire and demonstrate cognitive competencies? The article contains a definition of cognitive competencies. It explores their parameters and prime functions and proceeds to explore what we may refer to as the cognitive competencies of the computer or the amalgam of integrated circuits and their software capabilities. A comparison follows and gaps, overlaps and loopholes are identified. The conclusion is that computers have no logic, limited attention and fragile memory.

Military drones are given as an example for environmental self-awareness, a cognitive capacity gained through computer software

References

1. Rudroff, T., Rainio, O., & Klen, R. (2024). Neuroplasticity meets artificial intelligence: A hippocampus-inspired approach to the stability–plasticity dilemma. *Brain Sciences, 14*(11), 1111.
2. Powers, J. (2025, March 31). AI drones: How AI works in drones and examples. Built In. https://builtin.com/artificial-intelligence/drones-aicompanies.
3. Li, Y. (2017). Deep reinforcement learning: An overview. *arXiv preprint arXiv:1701.07274.*
4. Sharma, S. (2025, January 20). Open-source DeepSeek-RI uses pure reinforcement learning to match OpenAI's — at 95% less cost. VentureBeat. Retrieved January 26, 2025, from [invalid URL removed]
5. Oyedele Tioluwani. (2024, June 17). What are Attention Mechanisms in Deep Learning? FreeCodeCamp.org. https://www.freecodecamp.org/news/what-areattention-mechanisms-in-deep-learning/
6. Tobii. (n.d.). Attention computing: What is it and what could it mean for you? Retrieved from www.tobii.com/blog/attention-computing-what-is-it-and-whatcould-it-mean-for-y.

Citation: Namaki, El. (2026). Retired Dean, MSM, Netherlands. Dean, Artificial Intelligence Technologies (AIT), Canada. *Sustainable Energy and AI Technologies, 1*(1), 01-05.