INTERDISCIPLINARY APPROACHES TO LITERATURE AND NEUROSCIENCE: COGNITIVE STUDIES

RITU
Mail - ritukhatri765@gmail.com

ABSTRACT

Cognitive literary studies is a relatively new interdisciplinary field that combines literary studies with the sciences of the brain and mind. Here are some related topics:

Interdisciplinary approach to literary texts

This approach uses knowledge from various sciences to analyze literary texts and identify conditions of understanding.

Interdisciplinary approach to cognitive modeling

This approach uses a mathematical model to model cognition, particularly decision-making processes.

Cognitive science

This interdisciplinary field of research has flourished since the 1970s, and it closely collaborates with many disciplines, including psychology, philosophy, linguistics, and computer science.

Neuroscience

This interdisciplinary science has traditionally been considered a subdivision of biology, but it now works closely with many other disciplines, including psychology, medicine, and engineering

KEYWORDS: literature, neuroscience, interdisciplinary, cognitive, studies

DOI Number: 10.48047/nq.2022.20.8.nq221186 **NeuroQuantology 2022;20(8):11445-11454**

INTRODUCTION

If the historical separation of the humanities from the 'hard' sciences has been extensively theorized,22,23 the peculiar status of the cognitive sciences with respect to this division has only more recently come into focus.24,25 What distinguishes the cognitive sciences is not a reciprocal or even engagement with the humanities (if there is a 'cognitive turn' in the humanities,26 traces of a 'humanistic turn' in the cognitive sciences are, with few exceptions,27 absent), but rather their recruitment by disciplines such as literary studies,28 narratology,29,30 esthetics,31 or theology.32 While psychology, phenomenology, and philosophy of mind have exerted an influence on esthetic and cultural theory for over a century, only recently have experimental cognitive disciplines stimulated in the humanities such an array of enthusiasms, biases, and perplexities. Critiques of what has been termed 'neuromania'33 are two-pronged. On the one hand, it is argued that the proliferation of 'neuro-labels' (neuroaesthetics, neurotheology, and cognitive narratology) is a fashionable trend and signals no substantial innovation on research hypotheses and outcomes that could have been framed or obtained by already existing disciplines. On the other hand, there is a suspicion concerning the methodological ground of these new 'interdisciplines'. To what extent should neuroscientific methods inform humanistic research? Is this best conceptualized as a largely one-way interaction? And if not, how can the explanatory and interpretive toolkits of the humanities and social sciences modify the empirical and causal frameworks of cognitive sciences?

Among the supporters of the importance of the cognitive sciences for the esthetic field, Edward Slingerland34 has suggested that the cognitive sciences should provide a constraining function for humanistic research. This 'vertical integration'—according to which hypotheses and method within the humanities should be vertically limited by what the cognitive sciences say can be a testable truth—clearly assigns a hierarchical priority to the scientific field. In what follows we aim to provide a different definition of disciplinary integration based on individuals' interaction in the HtV project; a definition which can fully accommodate a mutual, more 'horizontal' exchange of methods and hypothesis between the cognitive sciences and humanities. [1,2,3]In referring to the mutual 'cannibalization' of theories and their unsystematic incorporation of sometimes conflicting claims, Jacques Derrida defined theories as 'monsters'.44 This monstrosity can be detected also in disciplinary umbrella terms such as 'literary studies', 'medical humanities', and 'cognitive sciences'. So varied are its contributing disciplines, and so heterogeneous are its approaches, that to treat the field of 'cognitive sciences' as a unitary agent in the interdisciplinary exchange is problematic, to say the least. The habit of speaking of disciplines as unified agents relates to our functional tendency to simplify and to anthropomorphize. But if disciplines are not individual, they are embodied in (and their existence and development rely on) individual human agents. Instead of approaching interdisciplinarity in the abstract terms of a theoretical integration, we propose to ground analysis in the actual interaction of what we can call individuals' disciplinary minds. This methodological turnaround, from a top-down categorization of interdisciplinarity to a bottom-up account, complements formulations of disciplinary actors and agents within science and technology studies, and has two important benefits. First, it reconceptualizes the abstract problem of disciplinary boundaries in terms of the boundaries of human minds and in terms thus amenable to cognitive inquiry. Secondly, by drawing on contemporary accounts of extended, embodied, and enactive cognition, it enables us to understand the 'unbounding'2 of disciplinary minds in interdisciplinary projects.

Cognitive sciences now strongly challenge the Cartesian idea that cognition is something that happens just 'in the head'.45 According to this new framework in the science of the mind,46 cognitive processes are instead partially extending into the world through the interaction with the environment and cognitive tools.40 The extended mind (EM) thesis assumes that the boundaries of the mind (the conceptual edges underlying the opposition of internal versus external space) become under certain conditions 'porous'.47 This porosity takes place when the mind interacts, manipulates and exploits external tools; when the mind couples with these externalities and constituting what EM theorists call a 'coupled system'. By drawing on recent expansions of this thesis into the social domain,48,49 in the next section, we want to suggest that, once we consider interdisciplinarity as the embodied and enactive interaction of individuals (shortly, as a human cognitive process) the same 'porosity' is activated in what we called 'disciplinary minds'. Furthermore, we propose a model that accommodates the same causal reciprocity and agency distribution between disciplinary minds that the EM thesis attributes to the mind–world interaction.

DISCUSSION

In the first decade of the twenty-first century, our understanding of the cognition of literature was transformed by scientific discoveries, such as the mirror neuron system and its role in empathy. Addressing questions such as why we care so deeply about fictional characters, what brain activities are sparked when we read literature, and how literary works and scholarship can inform the cognitive sciences, this book surveys the exciting recent developments in the field of cognitive literary studies and includes contributions from leading scholars in both the humanities and the sciences.

Beginning with an overview of the evolution of literary studies, the editors trace the recent shift from poststructuralism and its relativism to a growing interdisciplinary interest in the empirical realm of neuroscience. In illuminating essays that examine the cognitive processes at work when we experience fictional worlds, with findings on the brain's creativity sites, this collection also explores the impact of literature on self and society, ending with a discussion on the present and future of the psychology of fiction. Contributors include Literature and the Brain author Norman N. Holland, on the neuroscience of metafiction reflected in Don Quixote; clinical psychologist Aaron Mishara on the neurology of self in the hypnagogic (between waking and sleeping) state and its manifestations in Kafka's stories; and literary scholar Brad Sullivan's exploration of Romantic poetry as a didactic tool, applying David Hartley's eighteenth-century theories of sensory experience.[4,5,6]

Cognitive neuroscience is the scientific field that is concerned with the study of the biological processes and aspects that underlie cognition,[1] with a specific focus on the neural connections in the brain which are involved in mental processes. It addresses the questions of how cognitive activities are affected or controlled by neural circuits in the brain. Cognitive neuroscience is a branch of both neuroscience and psychology, overlapping with disciplines such as behavioral neuroscience, cognitive psychology, physiological psychology and affective neuroscience.[2] Cognitive neuroscience relies upon theories in cognitive science coupled with evidence from neurobiology, and computational modeling.[2]

Parts of the brain play an important role in this field. Neurons play the most vital role, since the main point is to establish an understanding of cognition from a neural perspective, along with the different lobes of the cerebral cortex.

Methods employed in cognitive neuroscience include experimental procedures from psychophysics and cognitive psychology, functional neuroimaging, electrophysiology, cognitive genomics, and behavioral genetics.

Studies of patients with cognitive deficits due to brain lesions constitute an important aspect of cognitive neuroscience. The damages in lesioned brains provide a comparable starting point on regards to healthy and fully functioning brains. These damages change the neural circuits in the brain and cause it to malfunction during basic cognitive processes, such as memory or learning. People have learning disabilities and such damage, can be compared with how the healthy neural circuits are functioning, and possibly draw conclusions about the basis of the affected cognitive processes. Some examples of learning disabilities in the brain include places in Wernicke's area, the left side of the temporal lobe, and Broca's area close to the frontal lobe.[3]

Also, cognitive abilities based on brain development are studied and examined under the subfield of developmental cognitive neuroscience. This shows brain development over time, analyzing differences and concocting possible reasons for those differences.

Theoretical approaches include computational neuroscience and cognitive psychology.

RESULTS

Literary scholars have increasingly taken up interdisciplinary frameworks, methodologies, and pursuits in recent years, despite the difficulties of "being interdisciplinary" cogently outlined by Stanley Fish. Such broad-based critical schools or tendencies as the new historicism, gender studies, and cultural criticism by definition stake out their ground between or across disciplines, and some literature departments have remade themselves as "cultural studies" programs, suggesting that interdisciplinarity is becoming not simply a legitimate option for literary scholars but may be gaining the force of an imperative - one all the harder to resist as university presses attempt to maximize sales with academic titles that can be marketed across disciplinary lines. It might seem initially surprising, then, that those challenging disciplinary boundaries in literary and cultural studies have shown so little interest in cognitive science, the major interdisciplinary initiative marking the convergence of linguistics, computer science, psychology, neuroscience, philosophy of mind, and anthropology. Our widespread lack of engagement with what has been called the "cognitive revolution" is all the more striking given its obvious bearing on theoretical discussions of language, subjectivity, and consciousness, not to mention its status as one of the most exciting and potentially far-reaching intellectual developments of the late 20th century. We hope to provoke such engagement - both critical and collaborative - in the essay that follows. We begin by sketching out some key developments in the constitution of cognitive science as a major interdisciplinary venture, emphasizing the transition from pioneering attempts to describe cognition in terms of the logical processing of coded symbols to more recent efforts to ground cognitive activity in embodied experience. We then look at a series of related issues in cognitive science of special interest to scholars of literature and culture, including categorization theory, nonarbitrary aspects of language, metaphoricity, agency, and the material character of thought. Finally, we survey a number of attempts to date, on the part of cognitive researchers and theorists as well as literary scholars and critics, to forge links between literary studies and cognitive science.[7,8,9] The first phase of the cognitive revolution, based initially in linguistics and computer science, successfully dislodged behaviorism as the dominant paradigm within the social sciences. Behaviorism held that only directly observable behaviors could provide a valid basis for scientific study, and that any speculation about the cognitive processes behind those behaviors was insupportable and therefore to be avoided. Reaching beyond the social sciences, the influence of behaviorism was also apparent in the New Critical "intentionalist fallacy" - with its injunction to study only the text as a mode of complex behavior, leaving aside any concern about the author's thoughts or intentions - and in the "affective fallacy" which similarly bracketed off the mental processes of the reader. Another behaviorist axiom, that human behavior is determined by environmental or cultural forces without reference to specific mental functions or constraints, still inheres within several current approaches to literary and cultural studies, such as Marxist and some new historicist criticism. In fields such as linguistics and psychology, however, behaviorism has for some time been largely discarded in favor of research into the cognitive processes of the brain. Noam Chomsky was the first outspoken critic of behaviorism, arguing in the 1950s that the human mind carried a linguistic capacity that was both innate and universal.

CONCLUSION

Cognitive neuroscience is an interdisciplinary area of study that has emerged from neuroscience and psychology.[4] There are several stages in these disciplines that have changed the way researchers approached their investigations and that led to the field becoming fully established.

Although the task of cognitive neuroscience is to describe the neural mechanisms associated with the mind, historically it has progressed by investigating how a certain area of the brain supports a given mental faculty. However, early efforts to subdivide the brain proved to be problematic. The phrenologist movement failed to supply a scientific basis for its theories and has since been rejected. The aggregate field view, meaning that all areas of the brain participated in all behavior,[5] was also rejected as a result of brain mapping, which began with Hitzig and Fritsch's experiments[6] and eventually developed through methods such as positron emission tomography (PET) and functional magnetic resonance imaging (fMRI).[7] Gestalt theory, neuropsychology, and the cognitive revolution were major turning points in the creation of cognitive neuroscience as a field, bringing together ideas and techniques that enabled researchers to make more links between behavior and its neural substrates.[10,11,12]

Origins in philosophy

Philosophers have always been interested in the mind: "the idea that explaining a phenomenon involves understanding the mechanism responsible for it has deep roots in the History of Philosophy from atomic theories in 5th century B.C. to its rebirth in the 17th and 18th century in the works of Galileo, Descartes, and Boyle. Among others, it's Descartes' idea that machines humans build could work as models of scientific explanation."[8] For example, Aristotle thought the brain was the body's cooling system and the capacity for intelligence was located in the heart. It has been suggested that the first person to believe otherwise was the Roman physician Galen in the second century AD, who declared that the brain was the source of mental activity,[9] although this has also been accredited to Alcmaeon.[10] However, Galen believed that personality and emotion were not generated by the brain, but rather by other organs. Andreas Vesalius, an anatomist and physician, was the first to believe that the brain and the nervous system are the center of the mind and emotion.[11] Psychology, a major contributing field to cognitive neuroscience, emerged from philosophical reasoning about the mind.[12]

One of the predecessors to cognitive neuroscience was phrenology, a pseudoscientific approach that claimed that behavior could be determined by the shape of the scalp. In the early 19th century, Franz Joseph Gall and J. G. Spurzheim believed that the human brain was localized into approximately 35 different sections. In his book, The Anatomy and Physiology of the Nervous System in General, and of the Brain in Particular, Gall claimed that a larger bump in one of these areas meant that that area of the brain was used more frequently by that person. This theory gained significant public attention, leading to the publication of phrenology journals and the creation of phrenometers, which measured the bumps on a human subject's head. While phrenology remained a fixture at fairs and carnivals, it did not enjoy wide acceptance within the scientific community.[13] The major criticism of phrenology is that researchers were not able to test theories empirically.[4]

Localizationist view

The localizationist view was concerned with mental abilities being localized to specific areas of the brain rather than on what the characteristics of the abilities were and how to measure them.[4] Studies performed in Europe, such as those of John Hughlings Jackson, supported this view. Jackson studied patients with brain damage, particularly those with epilepsy. He discovered that the epileptic patients often made the same clonic and tonic movements of muscle during their seizures, leading Jackson to believe that they must be caused by activity in the same place in the brain every time. Jackson proposed that specific functions were localized to specific areas of the brain,[14] which was critical to future understanding of the brain lobes.

Aggregate field view

According to the aggregate field view, all areas of the brain participate in every mental function.[5]

Pierre Flourens, a French experimental psychologist, challenged the localizationist view by using animal experiments.[4] He discovered that removing the cerebellum (brain) in rabbits and pigeons affected their sense of muscular coordination, and that all cognitive functions were disrupted in pigeons when the cerebral hemispheres were removed. From this he concluded that the cerebral cortex, cerebellum, and brainstem functioned together as a whole.[15] His approach has been criticised on the basis that the tests were not sensitive enough to notice selective deficits had they been present.[4]

Emergence of neuropsychology

Perhaps the first serious attempts to localize mental functions to specific locations in the brain was by Broca and Wernicke. This was mostly achieved by studying the effects of injuries to different parts of the brain on psychological functions.[9] In 1861, French neurologist Paul Broca came across a man with a disability who was able to understand the language but unable to speak. The man could only produce the sound "tan". It was later discovered that the man had damage to an area of his left frontal lobe now known as Broca's area. Carl Wernicke, a German neurologist, found a patient who could speak fluently but non-sensibly. The patient had been the victim of a stroke, and could not understand spoken or written language. This patient had a lesion in the area where the left parietal and temporal lobes meet, now known as Wernicke's area. These cases, which suggested that lesions caused specific behavioral changes, strongly supported the localizationist view. Additionally, Aphasia is a learning disorder which was also discovered by Paul Broca. According to, Johns Hopkins School of Medicine, Aphasia is a language disorder caused by damage in a specific area of the brain that controls language expression and comprehension.[16] This can often lead to the person speaking words with no sense known as "word salad" [17]

Mapping the brain

In 1870, German physicians Eduard Hitzig and Gustav Fritsch published their findings of the behavior of animals. Hitzig and Fritsch ran an electric current through the cerebral cortex of a dog, causing different muscles to contract depending on which areas of the brain were electrically stimulated. This led to the proposition that individual functions are localized to specific areas of the brain rather than the cerebrum as a whole, as the aggregate field view suggests.[6] Brodmann was also an important figure in brain mapping; his experiments based on Franz Nissl's tissue staining techniques divided the brain into fifty-two areas.

At the start of the 20th century, attitudes in America were characterized by pragmatism, which led to a preference for behaviorism as the primary approach in psychology. J.B. Watson was a key figure with his stimulus-response approach. By conducting experiments on animals he was aiming to be able to predict and control behavior. Behaviorism eventually failed because it could not provide realistic psychology of human action and thought – it focused primarily on stimulus-response associations at the expense of explaining phenomena like thought and imagination. This led to what is often termed as the "cognitive revolution".[18]

In the early 20th century, Santiago Ramón y Cajal and Camillo Golgi began working on the structure of the neuron. Golgi developed a silver staining method that could entirely stain several cells in a particular area, leading him to believe that neurons were directly connected with each other in one cytoplasm. Cajal challenged this view after staining areas of the brain that had less myelin and discovering that neurons were discrete cells. Cajal also discovered that cells transmit electrical signals down the neuron in one direction only. Both Golgi and Cajal were awarded a Nobel Prize in Physiology or Medicine in 1906 for this work on the neuron doctrine.[19]

Mid-late 20th century

Several findings in the 20th century continued to advance the field, such as the discovery of ocular dominance columns, recording of single nerve cells in animals, and coordination of eye and head movements. Experimental psychology was also significant in the foundation of cognitive neuroscience. Some particularly important results were the demonstration that some tasks are accomplished via discrete processing stages, the study of attention,[20][21] and the notion that behavioural data do not provide enough information by themselves to explain mental processes. As a result, some experimental psychologists began to investigate neural bases of behaviour. Wilder Penfield created maps of primary sensory and motor areas of the brain by stimulating the cortices of patients during surgery. The work of Sperry and Gazzaniga on split brain patients in the 1950s was also instrumental in the progress of the field.[9] The term cognitive neuroscience itself was coined by Gazzaniga and cognitive psychologist George Armitage Miller while sharing a taxi in 1976.[22]

Brain mapping

New brain mapping technology, particularly fMRI and PET, allowed researchers to investigate experimental strategies of cognitive psychology by observing brain function. Although this is often thought of as a new method (most of the technology is relatively recent), the underlying principle goes back as far as 1878 when blood flow was first associated with brain function.[7] Angelo Mosso, an Italian psychologist of the 19th century, had monitored the pulsations of the adult brain through neurosurgically created bony defects in the skulls of patients. He noted that when the subjects engaged in tasks such as mathematical calculations the pulsations of the brain increased locally. Such observations led Mosso to conclude that blood flow of the brain followed function.[7]

Commonly the cerebrum is divided into 5 sections: the frontal lobe, occipital lobe, temporal lobes, parietal lobe, and the insula.[23] The brain is also divided into fissures and sulci.[24] The lateral sulcus called the Sylvian Fissure separates the frontal and temporal lobes. The insula is described as being deep to this lateral fissure. The longitudinal fissure separates the lobes of the brain length-wise. Lobes are considered to be distinct in their distribution of vessels.[23] The overall surface consists of sulci and gyri which are necessary to identify for neuroimaging purposes.[24]

Notable Experiments

Throughout the history of cognitive neuroscience, many notable experiments have been conducted. For example, the mental rotation experiment conducted by Kosslyn et al., 1993,[25] indicated that the time it takes to mentally rotate an object via imagination takes the same amount of time as actually rotating it; they found that mentally rotating an object activates parts of the brain involved in motor functioning, which may explain this similarity.[25]

Another experiment is describes the two mechanisms of processing visual attention: bottom-up attention, and top-down attention.[26] They define bottom-up attention is the brain visually processing salient images first, and then the surrounding information, while top-down attention involves focusing on task-relevant objects first. The researchers found that the ventral stream focuses on visual recognition, the dorsal stream is involved in the spatial information concerning the object.

As experiments in cognitive neuroscience, what these have in common is that the researchers are measuring activities or behaviors that we can see, and then determining the neural basis of the function and what part of the brain is involved.

Emergence of a new discipline

Birth of cognitive science

On September 11, 1956, a large-scale meeting of cognitivists took place at the Massachusetts Institute of Technology. George A. Miller presented his "The Magical Number Seven, Plus or Minus Two" paper[27] while Noam Chomsky and Newell & Simon presented their findings on computer science. UlricNeisser commented on many of the findings at this meeting in his 1967 book Cognitive Psychology. The term "psychology" had been waning in the 1950s and 1960s, causing the field to be referred to as "cognitive science". Behaviorists such as Miller began to focus on the representation of language rather than general behavior. David Marr concluded that one should understand any cognitive process at three levels of analysis. These levels include computational, algorithmic/representational, and physical levels of analysis.[28]

Combining neuroscience and cognitive science

Before the 1980s, interaction between neuroscience and cognitive science was scarce.[29] Cognitive neuroscience began to integrate the newly laid theoretical ground in cognitive science, that emerged between the 1950s and 1960s, with approaches in experimental psychology, neuropsychology and neuroscience. (Neuroscience was not established as a unified discipline until 1971[30]). In the late 1970s, neuroscientist Michael S. Gazzaniga and cognitive psychologist George A. Miller were said to have first coined the term "cognitive neuroscience."[31] In the very late 20th century new technologies evolved that are now the mainstay of the methodology of cognitive neuroscience, including TMS (1985) and fMRI (1991). Earlier methods used in cognitive neuroscience include EEG (human EEG 1920) and MEG (1968). Occasionally cognitive neuroscientists utilize other brain imaging methods such as PET and SPECT. An upcoming technique in neuroscience is NIRS which uses light absorption to calculate changes in oxy- and deoxyhemoglobin in cortical areas. In some animals Single-unit recording can be used. Other methods include microneurography, facial EMG, and eye tracking. Integrative neuroscience attempts to consolidate data in databases, and form unified descriptive models from various fields and scales: biology, psychology, anatomy, and clinical practice.[32]

Adaptive resonance theory (ART) is a cognitive neuroscience theory developed by Gail Carpenter and Stephen Grossberg in the late 1970s on aspects of how the brain processes information. It describes a number of artificial neural network models which use supervised and unsupervised learning methods, and address problems such as pattern recognition and prediction.[33]

In 2014, StanislasDehaene, Giacomo Rizzolatti and Trevor Robbins, were awarded the Brain Prize "for their pioneering research on higher brain mechanisms underpinning such complex human functions as literacy, numeracy, motivated behaviour and social cognition, and for their efforts to understand cognitive and behavioural disorders".[34] Brenda Milner, Marcus Raichle and John O'Keefe received theKavli Prize in Neuroscience "for the discovery of specialized brain networks for memory and cognition"[35] and O'Keefe shared the Nobel Prize in Physiology or Medicine in the same year with May-Britt Moser and Edvard Moser "for their discoveries of cells that constitute a positioning system in the brain".[36]

In 2017, Wolfram Schultz, Peter Dayan and Ray Dolan were awarded the Brain Prize "for their multidisciplinary analysis of brain mechanisms that link learning to reward, which has far-reaching implications for the understanding of human behaviour, including disorders of decision-making in conditions such as gambling, drug addiction, compulsive behaviour and schizophrenia".,[37]

Recent trends

Recently the focus of research had expanded from the localization of brain area(s) for specific functions in the adult brain using a single technology. Studies have been diverging in several different directions: exploring the interactions between different brain areas, using multiple technologies and approaches to understand brain functions, and using computational approaches.[38] Advances in non-invasive functional neuroimaging and associated data analysis methods have also made it possible to use highly naturalistic stimuli and tasks such as feature films depicting social interactions in cognitive neuroscience studies.[39]

In recent years, there have been a lot of new advancements in the field of Cognitive Nueroscience. One new technique that has emerged is called shadow imaging. This method has combined different aspects of various neuroimaging techinques to create one that is more versatile. It uses standard light microscopy and melds it with fluorescence labeling of the interstitial fluid in the brain's extracellular space. This technique can help researchers get a bigger and more detailed look at brain tissue. This can help researchers understand more on anatomy and viability for their experiments. This technique has helped to see neurons, microglia, tumor cells and blood capillaries more closely. Shadow imaging is a new approach that shows a lot of promise in the field of neuroimaging.[13,14,15]

Another very recent trend in cognitive neuroscience is the use of optogenetics to explore circuit function and its behavioral consequences.[41] This new technology is a combination of genetic targeting of certain neurons and using the imaging technology to see targets in living neurons. This technique allows scientists to see the neurons while they are still intact in animals and be able to trace the electrical happenings in that cell. This new technology has been used successfully in many experiments and it is helping researchers in observing brain activity and understanding its role in disease, behavior and function.[42]

Researchers have also modified a fMRI and made it more efficient, in a technique called direct imaging of neuronal activity or DIANA. This group of researchers changed the software to collect data every 5 milliseconds, which is 8 times faster than what the normal technique captures. After, the software can stitch together all of the images taken during the imaging and create a full slice of the brain.[43]

Cognitive Neuroscience and Artificial Intelligence

Cognitive neuroscience has played a major role in shaping artificial intelligence (AI). By studying how the human brain processes information, researchers have developed AI systems that simulate cognitive functions like learning, pattern recognition, and decision-making. A good example of this is neural networks, which are inspired by the connections between neurons in the brain. These networks form the foundation of many AI applications.[44]

Deep learning, a subfield of AI, uses neural networks to replicate processes similar to those in the human brain. For instance, convolutional neural networks (CNNs) are modeled after the visual system and have transformed tasks like image recognition and speech analysis. AI also benefits from advancements in brain imaging technologies, such as functional magnetic resonance imaging (fMRI) and electroencephalography (EEG). These tools provide valuable insights into neural activity, which help improve AI systems designed to mimic human thought processes.[16,17,18]

Despite the progress, replicating the complexity of human cognition remains a challenge. Researchers are now exploring hybrid models that combine neural networks with symbolic reasoning to better mimic how humans think and solve problems. This approach shows promise for addressing some of the limitations of current AI systems.[19,20]

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