Artificial intelligence in neuroscience research

Janja Kopić[1], Ivica Kostović[1]

[1] Croatian Institute for Brain Research, School of Medicine, University of Zagreb, Croatia

Presenting Author:
Janja Kopić

ORCID:
0000-0002-4545-1329

E-mail:
janja.kopic@hiim.hr

Janja Kopić
Croatian Institute for Brain Research, School of Medicine, University of Zagreb, Croatia,
Salata 12, 1000 Zagreb
e-mail: janja.kopic@hiim.hr

Abstract:

Artificial intelligence (AI) is rapidly transforming neuroscience research by enabling faster, more precise, and large-scale analysis of complex biological and clinical data. This presentation explores the growing reciprocal relationship between neuroscience and computer science, where neuroscientific discoveries inspire novel computational models, while AI provides advanced tools for understanding brain structure and function (Farisco et al. 2024). Recent developments include the use of machine learning in neuroimaging, automated neuron tracing, behavioral analysis, and prediction of disease progression. AI-driven technologies such as digital twins, brain decoding systems, and biomarker analysis are opening new possibilities for personalized medicine and early diagnosis of neurological disorders, particularly Alzheimer's disease, epilepsy, and stroke (Silva et al. 2018). The presentation also highlights practical clinical applications of AI-based platforms for MRI, CT, EEG, and PET analysis, as well as modern tools for calcium imaging and motion tracking in experimental neuroscience. Comparisons between biological and artificial neural networks illustrate both the inspiration AI draws from the human brain and the current limitations of artificial systems in reproducing higher cognitive and social functions (Hassabis et al. 2017). Special emphasis is placed on developmental neuroscience and the complexity of human neural architecture compared to artificial neural networks. Finally, ethical, legal, and social challenges associated with the rapid development of AI are discussed (Ruiz-Vanoye et al. 2026). The future of neuroscience is presented as fundamentally interdisciplinary, requiring collaboration between medicine, biology, computer science, and ethics to ensure responsible innovation made for the common good.

Keywords: artificial intelligence, computational neuroscience, machine learning, neuroimaging, brain–computer interface

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This work was supported by the Croatian Science Foundation HRZZ-IP-2024-05-7157 (IK)

Artificial intelligence is not a brain (and why it matters)

Bojan Jerbić[1,2]

[1] CRTA - Regional Center for Excellence for Robotic Technologies
[2] Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb

Presenting Author:
Bojan Jerbić

ORCID:
0000-0003-1811-5669

E-mail:
bojan.jerbic@fsb.unizg.hr
bojan.jerbic@hazu.hr

Professor Emeritus
Faculty of Mechanical Engineering & Naval Architecture
University of Zagreb

Abstract:
Artificial intelligence is increasingly influencing the way we make decisions, communicate information, and organize work, including in healthcare. Since modern AI can generate fluent text and persuasive recommendations, the discourse often slips into an intuitive analogy: AI "understands" like the brain. However, the brain is an embodied biological system shaped by evolutionary pressures for energy efficiency, rapid learning from sparse experience, and robust adaptation to uncertainty. AI owes much to bioinspired artificial neural networks, but these models remain simplified computational abstractions rather than physiological reproductions of central nervous system functions. The performance of common AI models is usually achieved by scaling large datasets, high computing power, and extensive parameterization. In many AI systems, learning is primarily based on extracting statistical regularities from large datasets. In language models, this can resemble understanding because language is highly structured. Many philosophers who have studied language as a universal human phenomenon, such as Wittgenstein, Aristotle, and Plato, have argued that human intelligence is embedded in language and partly shaped or encoded in it. However, pattern competence is not equivalent to robust, context-sensitive and conscious intelligence (Farisco M, Evers K, Changeux JP. 2024).
A fundamental difference is in resource intensity: training and implementing high-performance models often requires significant computational infrastructure and energy, while the brain operates under strict metabolic constraints. It learns efficiently from limited experience and adapting robustly to new challenges. This contrast motivates the argument that AI's "hunger" for data and energy is not accidental, but symptomatic of the missing computational principles that biology exploits for efficiency and adaptability.
The solution may lie in **NeuroAI** (Davies M, Wild A, Orchard G, Sandamirskaya Y, et al. 2021), which is best described as a biologically inspired reengineering of AI, rather than an attempt to "build a brain in silicon". Fellous et al. (2026) position NeuroAI as a broad agenda that connects neuroscience and AI to develop more efficient, adaptive systems while advancing neuroscience itself. In NeuroAI roadmaps and neuroscience-inspired AI syntheses, recurring transferable principles include: **hierarchical, compressed representations** (abstraction over raw data); **inductive structure** that accelerates learning; **error-driven active learning**; **predictive coding** (Luu TM, Lee D, Yoo CD. 2023); **event-driven sparse computation** (activity driven by change) (Yao M, Hu J, Zhou Z, Yuan L, Tian Y, Xu B, et al. 2023); **closed-loop embodiment and learning** of perception and action (multimodal AI) (Figure 1).

Keywords: artificial intelligence, neurosciences; learning, consciousness; ethics

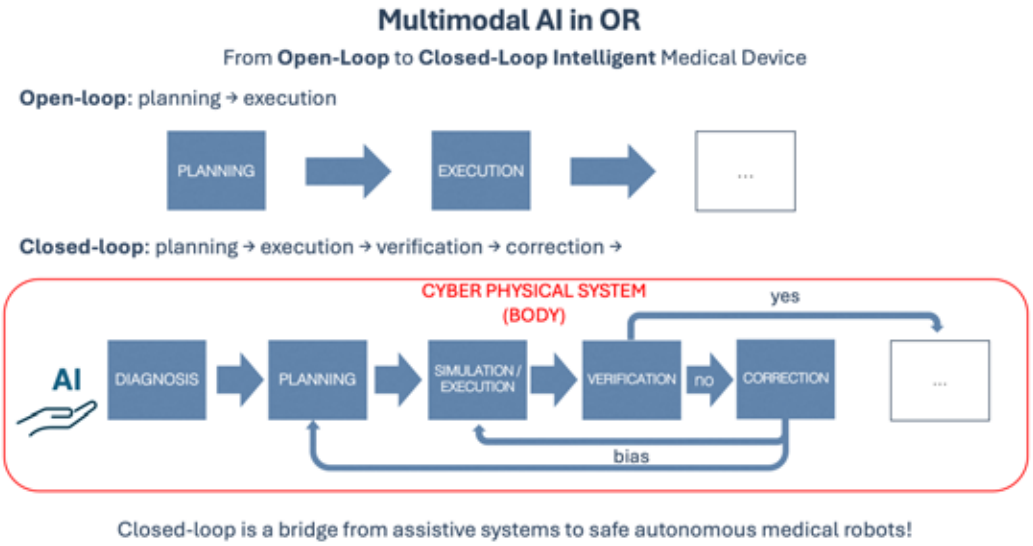

Figure 1. ***Multimodal AI*** *in OR, integrates imaging, sensing, physical devices, and clinical context (sw) to process real-time surgical decision-making and workflow coordination, by fusing these modalities, the system can provide context-aware assistance such as anatomical landmark recognition, trajectory guidance, risk alerts, instrument tracking, and workflow-aware prompts; from* ***Open-Loop*** *to* ***Closed-Loop Intelligent*** *Medical Device; closed-loop is a bridge from assistive systems to safe autonomous medical robots, it provides a practical pathway from surgeon-assistive systems to safe forms of autonomy because they support incremental delegation of subtasks while preserving predictability and safety, this approach enables* ***verifiable behavior, reproducible performance, and auditable decision traces****, which are essential in regulated, safety-critical medical settings.*

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Does neurogenesis persist in the adult human brain?

Mario Vukšić[1], Fran Božić[1]

[1] Croatian Institute for Brain Research, School of Medicine, University of Zagreb, Croatia

Presenting Author:
Mario Vukšić
Fran Božić

ORCID:
0000-0003-2196-2244
0000-0003-3228-1161

E-mail:
mario.vuksic@hiim.hr
fran.bozic@mef.hr

Mario Vukšić
Croatian Institute for Brain Research, School of Medicine, University of Zagreb, Croatia,
Salata 12, 1000 Zagreb
e-mail: mario.vuksic@hiim.hr

Abstract:
Adult neurogenesis, comprising the generation, differentiation, maturation, and integration of new neurons, has been extensively studied in experimental animals over the last three decades. Its discovery in the mammalian brain overturned the long-held dogma that the adult brain has no capacity for generating new neurons. Several studies have shed light on adult neurogenesis in humans by quantifying cells expressing neuroblast-associated markers in the human post-mortem brain. Despite long-standing scepticism, it is now increasingly accepted that new neurons are continuously added to discrete brain regions throughout adult life in various species, including humans. In mammals, adult neurogenesis has been described mainly in discrete neurogenic niches, particularly the subgranular zone of the dentate gyrus, while the extent of subventricular zone-associated neurogenesis in adult humans remains less clear. Adult-born dentate granule cells undergo several developmental stages, accompanied by gradual changes in their morphological and physiological characteristics (Fig. 1). Approximately two months after their birth, the basic structural and physiological properties of adult-born granule cells become largely indistinguishable from those of mature granule cells. One influential carbon-dating study estimated that approximately 700 new neurons are added daily in each adult human hippocampus, corresponding to an annual turnover rate of 1.75%. The proliferation, differentiation, and survival of these newly generated cells are regulated by distinct extrinsic factors, including exercise, environmental enrichment, stress, and inflammation. In addition, pathological conditions, such as epileptic seizures, can modulate the generation of new cells. Traumatic brain injury has also been reported to increase or dysregulate hippocampal neurogenesis. Given its unique and strategic position at the entry point of the hippocampal trisynaptic circuit, adult neurogenesis has been implicated in the initial processes of memory formation. In this context, adult neurogenesis has been proposed to contribute to key hippocampal functions, including novelty detection, temporal, spatial and emotional processing, pattern separation and completion, and memory consolidation. Overall, in the field of adult neurogenesis, the debate has increasingly shifted from its general existence toward its precise extent, regulation, and functional relevance in humans. The fact that the adult human brain retains the capacity to generate new neurons in the hippocampal dentate gyrus has sparked interest in its potential therapeutic applications. Recent reports note that “adult neurogenesis” appears as a keyword in 38 registered clinical trials, indicating growing translational interest in adult-born neurons as therapeutic targets. Thus, the discovery of adult neurogenesis in the human hippocampus has reshaped our understanding of brain plasticity and opened new avenues for research into learning, memory, and mental health. Nevertheless, despite substantial progress, important questions remain regarding its extent, regulation, and functional relevance in humans.

Keywords: dentate gyrus, granule cells, stem cells, memory, brain plasticity

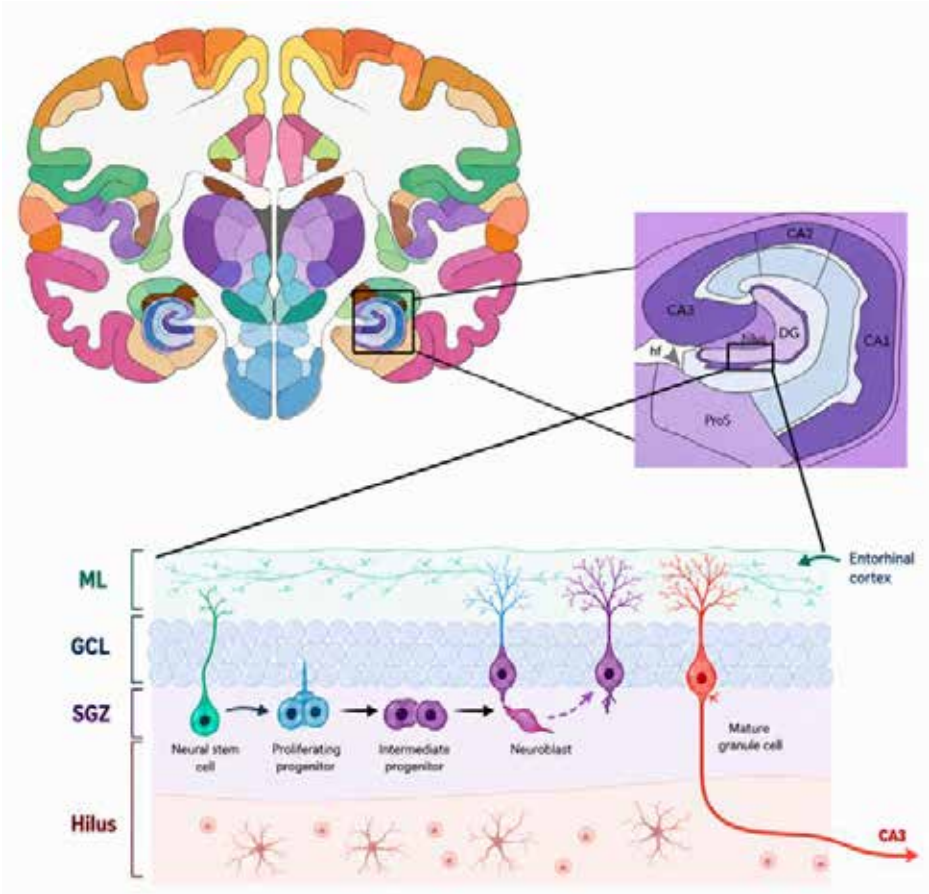

Figure 1. **Schematic representation of adult-born granule cell maturation in the dentate gyrus of the human hippocampus.** *Adult-born dentate granule cells arise from neural progenitor cells in the subgranular zone and progress through sequential developmental stages, including proliferating progenitors, intermediate progenitors, neuroblasts, and immature granule cells. During maturation, these cells extend dendrites into the molecular layer and project axons toward the CA3 field. By approximately two months after birth, adult-born granule cells acquire mature structural and physiological properties and become functionally integrated into hippocampal circuitry. ML = molecular layer, GCL = granule cell layer, SGZ = subgranular zone, DG = dentate gyrus, CA = cornu ammonis, ProS = prosubiculum, hf = hippocampal fissure.*

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This work was supported by the Croatian Science Foundation (HRZZ-IP-2024-05-5754)

The Social Brain and Decision-Making

Ivica Kostović[1]

[1] Croatian Institute for Brain Research, School of Medicine, University of Zagreb, Croatia

Presenting Author:
Ivica Kostović

ORCID:
0000-0002-4090-4114

E-mail:
ikostov@hiim.hr
ivica.kostovic@hiim.hr

Professor Emeritus, Croatian Institute for Brain Research, School of Medicine, University of Zagreb, Croatia

Abstract:
The complex social behaviour is most characteristic feature of the human nature. Morevoever humans display a number of unique behaviour such as emotional face expressions and emotional tears. It is a challenging question of the contemporary neuroscience of what extent neural proceses are specialized for social behaviour or shared with other „non social" neural functions (Lockwood et al. 2020). In our presentation at this year symposium „Recent advances in brain research" organized by HAZU we have attempted to review some aspects of these questions. The background for current opinion in this field was based on research presented at Neuroscience 2025, the meeting organized by Society for Neurosience in San Diego as well as our developmental studies. There is growing evidence that human social phenomena are very similar to the social behaviour observed in other mammals especially in primates and highly intelligent sea mammals such as dolphins : empathy, consolation, cooperation and strategic deception (Zhang et al. 2026). These beahvioural phenomena depend on well balanced integration of emotional and cognitive function in neocortical and limbic transmodal cortices and subcortical nuclei (amygdala (Bickart et al. 2014), septal nuclei). The recent fMRI studies of the social behaviour emphasize significance of the structues at the medial aspect of cerebral hemispheres which form continuum from medial prefrontal cortex via anterior cingulate, midcingulate to the medial parietal (precuneus) region (Rilling and Sanfey 2011). This cortical network is connected with subcortical amygdaloid nuclear compex. This cortico-subcortical network is collectively described as a „social brain" (Happé and Frith 2014, Chen and Hong 2018). Some investigators describe this medially-limbic located emotional executive and cognitive network as „meeting of the brains". The parahipocammpal gyrus with so called „conceptual neurons„ which serve for recognition of the special individual human face and enthorinhal hippocampal circuit are also important cognitive and memory neural systems for social behaviour. Neural networks for awards in social behaviour is integrated in orbito-frontal cortex which is connected with ventro-medial prefrontal cortex. In this prefrontal region moral and utility evaluation of the social behaviour are integrated. Recent research using fMRI and neurophysiological and neurological approaches confirms importance of dorsal and polar prefrontal cortex in strategic desicions in the social context. Empathy and uncertainty predictions are integrated in the insula which is burden in the depth of lateral cerebral fossa. In conclusion, recent evidence suggests that there are indeed brain regions implicated in social, emotional, and cognitive behaviour: transmodal prefrontal anterior, cingulate, medial, parietal, temporal, insular and parpahipocamppal cortices and related amygdala and thalamic nuclei. It is our opinion that future studies of these „social" brain areas should pay more attention to functional classes of specialized „social" neurons then to topographically defined connectivity. New approach should also explore significance of resting state fMR activity and neuronal networks involved in reference to self.

Keywords: social brain, decision making, social behaviour, fMRI, neural networks

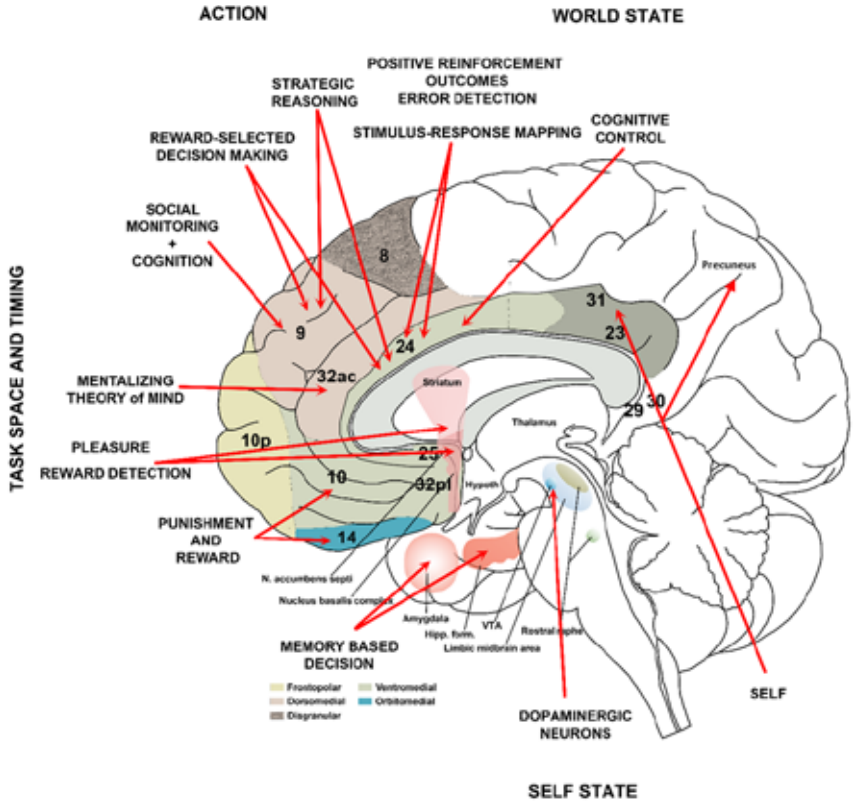

Figure 1. Areas included in social desicion making at the medial aspect of hemisphere

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This work was supported by the Croatian Science Foundation HRZZ-IP-2024-05-7157 (IK)