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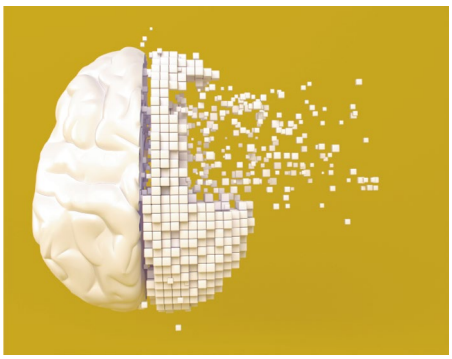
The new NeuroAI

After several decades of developments in AI, has the inspiration that can be drawn from neuroscience been exhausted? Recent initiatives make the case for taking a fresh look at the intersection between the two fields.



The effects of neuroscience on artificial intelligence (AI), and the mutual influence of the two fields, have been discussed and debated in the past few decades. Not long after the seminal workshop at Dartmouth College in 1956, which launched the field of AI, artificial neural networks called perceptrons were introduced by Rosenblatt. He studied them as simple models of brain-inspired systems following earlier work, including from McCulloch and Pitts, who introduced formal models of biological neurons, and from Hebb, who postulated the conditions under which the connection strengths of biological neurons change. Research on hierarchical processing in the visual system in the 1960s inspired the development of convolutional neural networks in the 1980s. However, as AI research has evolved at a fast pace, progress over recent years has stirred a divergence from this original neuroscience inspiration. The pursuit of more powerful artificial neural systems in leading AI research labs, particularly those affiliated with tech companies, is currently focussed on engineering. This pursuit emphasizes further scaling up of complex architectures such as transformers, rather than integrating insights from neuroscience.

A recent panel discussing the role of neuroscience in contemporary AI research and the extent of their mutual influence was convened at COSYNE, the leading computational and systems neuroscience conference. The panel involved Anthony Zador (Cold Spring Harbor Laboratory), Alexandre Pouget (University of Geneva), Blaise Aguera y Arcas (Google), Kim Stachenfeld (Google DeepMind and Columbia University), Jonathan Pillow (Princeton University) and Eva Dyer (Georgia Institute of Technology), with Paul Middlebrooks (host of the Brain-Inspired podcast) moderating.

Interestingly, the panellists did not seem to agree on the extent to which neuroscience currently influences and is influenced by AI research. For example, Aguera y Arcas believes that, historically, progress has resulted at times of convergence between the two fields and that, even though this does not seem to be the case now, in the future we might discover parallels between transformers and brain computation. This optimism was echoed by Zador, who argued that neuroscience has provided key insights for AI. He stated that the missing piece in current AI methods may come from basic research in neuroscience. By contrast, Pouget stated that although neuroscience labs are pushing hard to discover fundamental principles that can be incorporated into AI, nothing especially convincing has emerged in the past three decades, whereas, in contrast, neuroscience research has been profoundly influenced by recent developments in AI. This seems to be confirmed by Stachenfeld's comment that the use of AI methods in brain research is a 'low-hanging fruit' that has influenced the way neuroscience research is pursued at Google DeepMind. Dyer noted that with the shift of AI towards transformers and other complex architectures, the field seems to have moved away from its neural-inspired roots; however, AI may still look towards neuroscience for help in understanding complex information processing systems.

The COSYNE panel forms part of a recent coalition of initiatives around 'NeuroAI', a push to identify fresh ideas at the intersection between neuroscience and AI. For example, Neuromatch, a platform facilitating global collaboration in computational sciences, has developed a NeuroAI course scheduled for July 2024 on the common principles of natural and artificial intelligence. Other programs that promote interdisciplinary collaboration include the Cold Spring Harbor NeuroAI program, which will hold its third conference 'From neuroscience to artificially intelligent systems' in autumn 2024. Academic institutions are embracing NeuroAI, as evidenced by NeuroAI and Intelligent Systems at Princeton University and UCL NeuroAI at University College London, which encourage collaboration between the neuroscience and AI communities.

Scientific meetings such as COSYNE have a crucial role in convening researchers drawn to ideas that transcend traditional academic boundaries. In a perspective article on the origins of COSYNE[1], Zador highlights how such meetings create and nurture communities, such as theoretical and experimental neuroscientists, while facilitating the exchange of scientific languages. During the Q&A session of the COSYNE panel discussion, Pouget emphasized the roles of neuroscience, cognitive science and AI in understanding the brain, and expressed concerns about the limited representation of contributions from cognitive science and cognitive neuroscience at the conference. This frustration prompted researchers in these fields to establish the Cognitive and Computational Neuroscience Conference (CCN), which organized its first meeting in 2017. Although distinct, CCN and COSYNE complement one another, offering intriguing prospects for exploring how the different approaches — systems neuroscience versus cognitive science and cognitive neuroscience — shape and are shaped by AI.

Overall, the extent of the role of neuroscience in AI research, and that of AI in neuroscience research, remain open questions for the future. However, these two fields are deeply linked, and the exchange of ideas between them continues to evolve. The upcoming generation of scientists will need to possess fluency in both domains, making interdisciplinary programs such as Neuromatch and conferences such as COSYNE and CNN indispensable. The (re)emergence of NeuroAI will prompt researchers to explore the crucial questions necessary for uncovering some of the brain's computational principles that have remained elusive, paving the way for the development of more intelligent machines.

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References

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