

A pattern of diffusion of artificial intelligence in science: the development of an AI scientific specialty in neuroscience

Keywords: Science of science, scientometrics, Artificial Intelligence, knowledge diffusion, technological specialization

Extended Abstract

Artificial intelligence (AI) commonly refers to both a research program and, more generally, a set of complex computer-based programs which aim to mimic human mind processes with high reckoning power. These algorithms are amenable to applications in a variety of disciplines which use them for scientific advancements and which sometimes improve them for their conceptual and methodological needs. From this assertion we formulate the hypothesis that AI is an “adjacent possible” in Kauffman’s sense (2000), that is, AI first emerged in a specific scientific and technological context thanks to a combination of existing knowledge or innovations, and it is now expanding by blending with other novelties from specific disciplines and by reshaping some disciplinary practices and knowledge structures.

This work intends to address the process of diffusion of AI in neuroscience in a scientometric manner within this framework, namely how some AI-related knowledge have been brought from different scientific disciplines or specialties into neuroscience, and then how they are used. The corresponding underlying dynamics can be captured through both the disciplinary ecosystem around the whole neuroscience and the structure of collaborations among the scientists involved in this field of research.

So we first build a neuroscience bibliometric corpus extracted from the Microsoft Academic Knowledge Graph database (Färber, 2019), in which we separate AI-related articles from non-AI ones with a dedicated keywords’ filter applied to the titles and abstracts, that is provided by Gargiulo et al. (2022). This corpus includes scientific articles published in peer-reviewed journals between 1970 and 2019. Then we explore specifically the development of a dedicated AI specialty in neuroscience with its own scientific community by conducting analyses of both the egocentric citation network around these neuroscience articles and the associated co-signature network.

From the citation network we first propose an aggregated cartography of the main fields of research cited by these articles, as well as those that are most impacted by them just one year after publication. The first one illustrates a particular evolution of both AI-related references and generated citations that is not borrowed by the core of the neuroscience literature. Indeed this indicates a progressive specialization of references toward computer science, mathematics and engineering, while its impact is more broadly distributed across the entirety of the neuroscience field (see Fig.1A), mainly into engineering and neuroimaging technologies for clinical research and medicine. This preliminary analysis also indicates a technological transition both in references and generated citations in neuroscience AI research, that seems to occur around the 1990’s just after the second AI winter.

To reinforce these findings, the time-aggregated co-signatures network, including the main collaborations since 1970, first exhibits a small set of researchers (around 1.3% of them) that together have authored the most publications in AI research in peer-reviewed journals oriented toward computational neuroscience, mostly based on neural networks, and that does not maintain links with the rest of neuroscience community which does not publish AI research (see z-scores heat-map on Fig. 1B). The common disciplinary background of this core of ‘outsider’ scientists (Crane, 1969) shifts around the 1990’s from an interdisciplinary one centered around the native disciplines of AI and neuroscience, notably psychology,

cognitive science, mathematics, to a technological one centered mainly around computer science and engineering. More precisely, the second wave is made up of authors who are not fully involved in the neuroscience field and who are keeping to publish within their original disciplines.

According to the state of the art of the formation of a scientific specialty encountered in science studies, this work thus shows through AI in neuroscience a pattern of diffusion of knowledge in a scientific field of research, namely a formation and a transformation of a special AI-research alongside neuroscience, with its own evolving scientific community and bibliographic references, and which seems though to contribute to the main challenges of this field of research.

References

- Crane, D. (1969). Social Structure in a Group of Scientists: A Test of the "Invisible College" Hypothesis. *American Sociological Review*, 34-3, 335-362.
- Färber, M. (2019). The Microsoft Academic Knowledge Graph: A Linked Data Source with 8 Billion Triples of Scholarly Data. In C. Ghidini, O. Hartig, M. Maleshkova, V. Svátek, I. Cruz, A. Hogan, J. Song, M. Lefrançois, & F. Gandon (Éds.), *The Semantic Web – ISWC 2019* (Vol. 11779, p. 113-129). Springer International Publishing.
- Gargiulo, F., Fontaine, S., Dubois, M., Tubaro, P. (2022). A meso-scale cartography of the AI ecosystem. Available in : <http://arxiv.org/abs/2212.12263>.
- Kauffman, S. A. (2000). *Investigations*. Oxford University Press.

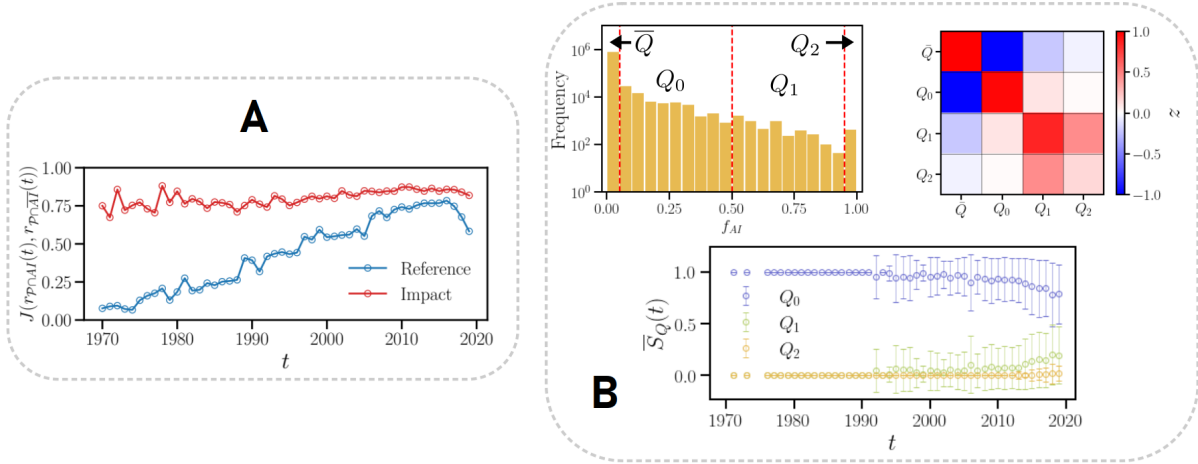


Figure 1. **A:** Temporal Jaccard index between AI and non-AI rankings of disciplines appearing in references (blue) and generated citations (red) in the neuroscience corpus (P). It shows a progressive uniformization of references in both corpora while the generated citations keep to be similar in the studied period. **B:** Top left: Distribution of the share of AI-related publications per author (left), separated in quartiles. Top right: Z-score matrix of the number of edges shared between the quartiles compared to randomized collaboration networks based on the same set of authors. Bottom: Temporal average share of quartiles within AI-related neuroscience publications. It indicates that the latter were first published by scientists only within Q_0 until the 1990's, and are now published by collaborations among all the quartiles, the last two being both characterized by the highest expertise in AI.