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Pattern recognition, gestalt and qualitative aspects of cognition: An information topology perspective

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The presentation focuses on recent and older results of elementary quantitative and qualitative aspects of consciousness and cognition and tackles the question "What is consciousness?" conjointly from biological, neuroscience-cognitive, physical and mathematical points of view. It proposes to unify various results and theories by means of algebraic topology and puts forward the suggestion that information topology is a particularly appropriate formalism to achieve such an aim. The resulting discrete probabilistic and group-theoretic principles and structures governing the theory of consciousness underline its galoisian nature. The first part presents the postulates and results on elementary perception in psychophysics and neuroscience at various organizational scales of the nervous system and proposes the hypothesis of an electrodynamic intrinsic nature of consciousness which is sustained by an analogical code. It underlines the diversity of the learning mechanisms that sustain the dynamics of perception and consciousness, including adaptive and homeostatic processes on multiple scales, and details their current generic expression within probability and information theory. The second part investigates the logical aspects of cognition and consciousness and proposes an axiomatization based on measure and probability theory. Topos and constructive logic are presented as providing an intrinsic non-deterministic-probabilistic logic, with the long-term aim of avoiding the paradoxical decomposition induced by the Axiom of Choice. Using such a basis, we sketch an elementary procedure allowing an expression of the information of a mathematical formula a la Gödel. We then present the formalism of information topology and propose that it provides a preliminary basis for synthesizing the main models of cognition and consciousness within a formal Gestalt theory. Information topology establishes a characterization of information theory functions, allowing for a precise expression of information structures and patterns. It provides a quantification of the structure of statistical interactions and their expression in terms of statistical physics and machine learning. Notably, those topological methods allow conciliation of some of the main theories of consciousness, namely integrated information theory, the global neuronal workspace model, the free energy principle and logical dynamics. The topological approach point out that consciousness is a structural phenomenon arising from collective interactions. Underlining the central role of invariance to transformation in neuroscience and perception, we further propose a possible correspondence of information topology with dynamical system theory and the related quantification of arousal states.

Biography

Pierre Baudot studied Biology at magister of ENS Ulm and had his Master degree in Cognitive Science and; PhD in Electrophysiology of Vision, Neural Coding and Learning at UNIC lab under the supervision of Y Fregnac. He notably studied the reproducibility and the information processing in natural condition of viewing with eye movements, and identified key nonlinearities in V1 receptive fields. Developing a formalization of multivariate mutual-information to catch statistical structure in complex systems, he joined D Bennequin at the Mathematical Institute of Jussieu and Complex System Institute (ISC-PIF) in 2006. They realized that information theory provides a very natural cohomology. To develop the applications of this framework to data analysis and pattern detection, he joined the team of J M Goaillard at UNIS, and unraveled specific high dimensional modules and clusters of genes expression in Dopaminergic Neurons of the SNc. He is now researching on automatic detection of cancers at Median Technologies. He was notably awarded the K2 trophy 2017 in Mathematics and Applications.

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