Information Theory for the Analysis of Physiological Networks

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In the emerging field of network physiology [1], the human organism is viewed as an integrated network where the cardiac, circulatory, respiratory, and cerebral systems, each with its own internal dynamics, continuously interact with each other to preserve the overall physiological function. In this seminar, I will present an unifying approach for the quantitative description of this network framed in the novel research field of information dynamics [2]. The approach is based on interpreting the physiological systems as dynamical systems, mapping their behavior into a set of variables, and describing the time evolution of these variables by means of information-theoretic analysis tools. These tools dissect the general concept of 'information processing' into basic elements of computation such as the new information produced by a system at each moment in time, the information stored in the system, the information transferred to it from the other connected systems, and the synergistic or redundant modification of the information transferred from multiple source systems to a target system. After presenting classic and novel estimators for these measures, their application to Network Physiology will be presented, including the study of the short-term cardiovascular and cardiorespiratory control at rest and during stress, the quantification of brain-heart interactions during sleep, and the description of the network which coordinates muscles across the body during pointing tasks.

[1] Bashan A, Bartsch RP, Kantelhardt JW, Havlin S and Ivanov PC, Network physiology reveals relations between network topology and physiological function. Nature Communications 3, 2012
[2] L Faes, A Porta, G Nollo, M Javorka, 'Information decomposition in multivariate systems: definitions, implementation and application to cardiovascular networks', Entropy, 2017, 19(1), 5.