Assessment of Central-Cardiorespiratory Network Pathways

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The analysis of couplings within and between dynamic systems has become more and more a topic of great interest in different fields of science. Especially in the medical field, the understanding of driver-response relationships between regulatory systems and within sub-systems is of growing interest. In particular, the focus has moved towards the multivariate assessment of the strength and the direction of such couplings for a better understanding of physiological regulatory mechanisms. Especially, the new interdisciplinary field of Network Physiology is getting more and more into the focus of interest in medicine. Network Physiology aims to define healthy and diseased physiological network states by analyzing structural, dynamical and regulatory alterations in the interaction of physiological systems and sub-systems.

We investigated the central-cardiorespiratory network (CCRN) applying linear and non-linear causal coupling approaches (Normalized Short Time Partial Directed Coherence and Multivariate Transfer Entropy). The focal point of interest was to figure out how different regulatory mechanisms of the central nervous system (CNS) and autonomic nervous system (ANS) influence or respectively compose the CCRN.

In this respect, we applied the methods In several extensive studies with age-gender matched healthy subjects (CON) under resting conditions compared to patients suffering from a neuropathological disease (paranoid schizophrenia - SZO). From all participants, continuous heart rate (successive beat-to-beat intervals, BBI), synchronized calibrated respiratory inductive plethysmography signal (respiratory frequency, RESP), and the mean power EEG from a 64-channel EEG (in relation to RR-intervals) were recorded for 15 min under resting conditions.

For SZO in comparison to CON we found that the central-cardiorespiratory coupling was a bidirectional one, with reduced central driving mechanisms towards BBI and RESP (EEG→BBI, EEG→RESP) and stronger respiratory and cardiac driving towards EEG (RESP→EEG, BBI→EEG). Interestingly, the enhanced coupling from the ANS to the CNS was only detectable with the linear coupling analysis, but not with the nonlinear one. This is a sign of a rigid altered coupling in order to maintain autonomous regulation despite pathological changes.

We could demonstrate a considerably significantly different central-cardiorespiratory network behaviour in schizophrenia with reduced central influence on the cardiac and respiratory system and a stronger respiratory and cardiac influence on the central nervous system. Moreover, this study provides a more in-depth understanding of the interplay of the central and autonomic regulatory network in healthy subjects and schizophrenia.