Cardiovascular and Cardiorespiratory Interactions – From Physiological Mechanisms to Clinical Applications
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From Understanding to Control: A Dynamical Systems Approach in Physiology

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I will present results showing how dynamical systems theory has led to new insights into physiological systems through the development of novel data-analysis methods and tools for modifying system dynamics toward more desirable states.

Inferring causal connections in complex physiological systems is a key element in understanding the normal and pathological behavior of observed systems. In recent years, we have developed a new causality analysis method, termed Dimensional Causality (DC), which can detect and distinguish the basic forms of causal relationships between two dynamical systems based on observed time series. DC can detect directed causal connections and circular or bidirectional interactions, and can distinguish these from two unconnected systems driven by a hidden common cause, or confounder. Results of DC analyses will be presented for data ranging from in vitro to in vivo epilepsy experiments, fMRI time series recorded during cognitive tasks,

and interactions within the cardiovascular and pulmonary systems. In these applications, our analysis emphasizes and quantifies the role of hidden, unobservable drivers.

Of course, we would like not only to analyze and understand physiological systems, but also to modify their dynamics, moving them away from pathological behavior toward normal states. I will show how dynamical systems theory can help identify escape routes from pathological dynamics of the epilepsy and, when combined with machine learning, can be used to define optimal stimulation strategies for efficiently terminating epileptic seizures.