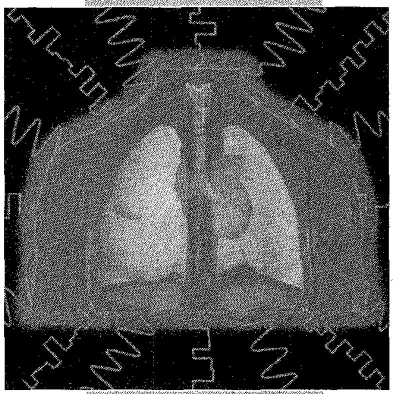

From the Guest Editor

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Nonlinear Dynamics of the Cardiorespiratory System

Healthy physiological systems generally display complex- or random-looking fluctuations even when in a fixed environment. The term "homeostasis" was coined early in the century to describe this behavior, which goes against the intuitive notion of stability leading to a fixed and steady state. In the last two decades, nonlinear dynamics, synergetics, and chaos have offered attractive metaphors for homeostasis. In elaborating on these metaphors and placing them on a precise basis backed by experimental and empirical evidence, it is necessary to quantify the nonlinear interactions and coordination of physiological systems. Although linear methods of modeling and data analysis are well established, nonlinear techniques are far less mature and there are many possible pitfalls in their approach. To give an overview of the current state of the art, and to suggest ways for the development of appropriate nonlinear methods, we have assembled here a short series of interrelated articles.

The series starts with an introduction to the theoretical background of nonlinear dynamics in the article "Nonlinear Coordination of Cardiovascular Autonomic Control" by Hoyer, Pompe, Herzel, and Zwiener. Then several exemplary individual approaches to different aspects of nonlinear coordination in the cardiovascular-respiratory system are presented:

Mathematical modeling and simulation is an appropriate tool to uncover those mechanisms that cannot be sufficiently investigated in physiological experiments. An interesting new application is presented in "Investigating the Dynamics of Atrioventricular Delay" by Seidel and Herzel.

Mean dependencies between coupled quantities can be investigated by means of their coordinated flow, such as presented in "Determinism in Bivariate Cardiorespiratory Phase-Space Sets" by Hoyer, Kaplan, Schaaff and Eiselt as well as in "Using Mutual Information to Measure Coupling in the Cardiorespiratory System" by Pompe, Blidh, Hoyer, and Eiselt. In this connection, the technique of multivariate surrogate data is an important tool, as reported and applied in "Detecting Nonlinearity and Phase Synchronization with Surrogate Data" by Palus and Hoyer.

Particular synchronization modes were found with regard to instantaneous phase relations, such as presented in "Synchronization in Noisy Systems and Cardiorespiratory Interaction" by Rosenblum, Kurths, Pikovsky, Schäfer, Tass, and Abel as well as in "Analyzing Entrainment of Heartbeat and Respiration with Surrogates" by Seidel and Herzel.

Finally, a short review of various trends in nonlinear systems analysis is given in "New Systems-Analytical Approaches to Nonlinear Coordination" by Hoyer, Kaplan, Palus, Pompe, and Seidel.

The authors thank Alvin Wald as editor of *IEEE EMB Magazine* for encouraging us to organize this review of actual research of nonlinear coordination as a series based on current discussions and actual results.

Invocation

In the last few years I have received much feedback both from the biomedical engineering and medical communities. There is particular interest in "nonlinear dynamics and coordination" in the body and its changes due to pathology; however, the knowledge of the principles and the practical applications is quite different. Since we all learn from the interactions between the different sciences, what we actually need is a living scientific network of nonlinear dynamics methods and applications in medicine.

Therefore, I offer to create a platform for exchange of methods, data, results, and experiences. This should support personal contacts, scientific cooperation, common publications, and conferences. It all starts with "networking," and I have found my networking experiences while attending IEEE-EMB conferences and during the composition of this special issue to be very encouraging. However, a successful permanent network would need an international team of intelligent contributors.

I am looking forward to your suggestions by e-mail (idh@mti.uni-jena.de).