Phase Resetting in Medicine and Biology

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Peter A. Tass

Phase Resetting in Medicine and Biology

Stochastic Modelling and Data Analysis

With 129 Figures, 7 in Color

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ISSN 0172-7389

Library of Congress Cataloging-in-Publication Data

Tass, Peter A., 1963-
Phase resetting in medicine and biology: stochastic modelling and data analysis / Peter A. Tass.
p. cm. – (Springer series in synergetics, ISSN 0172-7389)
Includes bibliographical references and index.
ISBN 978-3-540-38159-4 ISBN 978-3-540-38161-7 (eBook)
DOI 10.1007/978-3-540-38161-7
1. Computational neuroscience. 2. Stochastic analysis. 3. Oscillations. 4. Synchronization. I. Title. II. Series.
QP357.5.T37 1999 612.8'13–dc21 99-25203

Originally published by Springer-Verlag Berlin Heidelberg New York in 1999
Softcover reprint of the hardcover 1st edition 1999

Typesetting: Camera ready by the author using a Springer TEX macro package
Cover design: *design & production*, Heidelberg
Computer to film: Mercedesdruck, Berlin
SPIN: 10708993 55/3144/di - 5 4 3 2 1 0 – Printed on acid-free paper

To my mother,
Gertraud Tass,

to my sister,
Ute Tass,

and to the memory of my father,
Alexander Tass

Preface

Synchronization processes are of great interest and importance in biology, medicine and physics. In particular, for the comprehension of brain functioning it appears inevitable that one should analyze neuronal synchronization processes. This book presents a new understanding of how a stimulus influences synchronization patterns of a population of oscillators. On the one hand, a variety of stimulation-induced dynamical phenomena will be presented; on the other hand, new data analysis tools will be developed which will serve as a link between theory and experiment. In this way it will be possible to use the theory presented here as a basis for the design and evaluation of stimulation experiments and stimulation techniques in medicine and biology. We shall focus particularly on applications concerning the analysis of magnetoencephalography (MEG) and electroencephalography (EEG) data as well as deep brain stimulation techniques used in Parkinsonian patients.

This book addresses graduate students, professors and scientists in various fields including biology, mathematics, medicine, neuroscience, physiology and physics. Besides mathematically involved parts, the book also provides the reader with numerous illustrations and explications of the deep dynamical principles governing stimulation-induced desynchronization and synchronization processes. Therefore this book will be of interest to a general readership, and those who are not familiar with mathematics should not be deterred by the formulas. Indeed, some parts of the book are written particularly for neurologists, neuroscientists, neurosurgeons, and physiologists who may profit from this new approach, e.g., by applying it to MEG and EEG analysis or to the improvement of stimulation techniques in neurology and neurosurgery.

I hope that this book will bear fruit in medicine and that it will contribute to a physiology which appropriately takes into account the importance of regulatory and self-organizing processes. In my opinion Hermann Haken's synergetics is a perfectly suitable theoretical basis for the study of such physiological processes. Since modern computer facilities make it possible to apply these theoretical tools to biological data very effectively, we have good prospects of revealing the tremendous beauty and significance of holistic regulatory dynamics in physiology.

It is my desire to thank my teachers, friends and colleagues: First of all my thanks go to Prof. Hermann Haken for being an outstanding and

inspiring teacher, for his kind and continuous support, for much friendly advice, for our stimulating discussions, and for numerous fruitful comments on the manuscript. I consider it an honour and a pleasure to publish this book in the Springer Series of Synergetics.

When I came back to medicine after studying physics and mathematics, Prof. H.-J. Freund made it possible for me to do research in a neurological department with excellent scientific activities and equipment. I am very grateful for his visionary confidence and his superb support which enabled me to perform the studies presented in this book. Moreover, I would like to thank him for his marvellous teaching and for our inspiring discussions.

I express my special thanks to all colleagues in Düsseldorf, particularly, to PD Dr.Dr. H. Hefter for his deep and stimulating interest in investigating oscillatory processes in neurology, for his very kind support, and for our wonderful collaboration. My thanks go to Dr. A. Schnitzler and Dr. J. Volkmann for numerous fruitful discussions and a marvellous collaboration in the field of magnetoencephalography. Additionally, I am very grateful for the very friendly and fruitful collaboration with Dr. G. Fink, Dr. K. Müller, J. Salomon, F. Schmitz, Dr. P. Weiß, and Dr. J. Weule. I gratefully acknowledge the financial support of my studies by the German Science Foundation (SFB 194, A5).

My warmest thanks go to Prof. A. Wunderlin, for his great and sophisticated teaching, for carefully reading the manuscript, and for our enriching discussions.

I am very grateful to Prof. J. Kurths, Dr. M. Rosenblum, Prof. A. Pikovsky, G. Guasti, C. Raab, and Dr. H. Voss for our successful and stimulating common studies. The intensive collaboration with Prof. J. Kurths and Dr. M. Rosenblum is a pure joy.

Prof. K. Kirchgässner accompanied my work in an inspiring, tireless and very friendly way for which I would like to express my special thanks.

I am very indebted to Prof. H. Schmid-Schönbein for his encouraging and important support and his enormous efforts to establish an integrative and synergetic physiology.

Many thanks go to Prof. D. Epstein for our collaboration, for the many stimulating discussions, and for his kind and wise advice.

I am very grateful to Dr. D. Ebert for the many interesting discussions and for his permanent and friendly interest in my studies.

I thank the staff of Springer-Verlag for the excellent cooperation, in particular, Prof. W. Beiglböck, Ms. G. Dimler, Mr. F. Holzwarth, Dr. A. Lahee, Ms. E. Pfendbach, and Ms. B. Reichel-Mayer.

Last but not least I thank G. Burghardt, H. Hefter, I. Kupisch, L. Raiber, P. Weiß, and S. Wosch for their humour, support and sympathy.

Düsseldorf, January 1999 *Peter A. Tass*

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