



# Motor Learning and Control

FROM THEORY TO  
PRACTICE

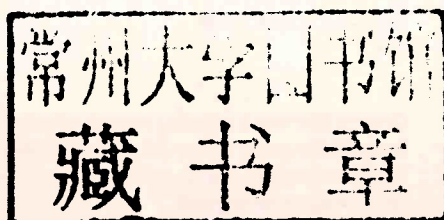
William H. Edwards

# Motor Learning and Control

From Theory to Practice

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# DEDICATION

*For Barbara*

# PREFACE

The scholarly study of motor learning and control is one of the most fascinating as well as practical of academic disciplines. The fabric of our daily activities is stitched together by thousands of individual motor acts every day. Being able to move—and beyond that, to move skillfully—not only makes life possible but shapes and gives purpose to our lives. The first objective in writing this book was to convey something of the excitement and essential character of this important area of inquiry and scholarship to students studying for careers in movement-related fields. I know from experience that unless students are initially engaged by and interested in a subject, no amount of academic planning and rigor, no manner how well-conceived, will prove favorable in gaining their best efforts and in optimizing their learning potential. In writing this book, I have made every attempt to present information in ways that are meaningful, accessible, and thought provoking to its readers.

A second primary purpose of this book was to offer a comprehensive and contemporary overview of the major areas of study in motor learning and control. Moreover, a major purpose was to present these from the several different perspectives applied to scholarly study and research in the field today. Until fairly recently, the scholarly study of motor skills has been the purview of one dominating theoretical perspective or another, with the particular perspective in vogue at any time shifting with the winds of the favored psychological theories of the day. Today that has changed. Motor learning and control have become major areas of study within a wide variety of disciplines, including neural science, cognitive psychology, computer science, engineering, robotics, developmental studies, philosophy, and kinesiology. The careers in which skill development plays an essential role have also expanded from traditional fields of athletics and physical education, and now include physical and occupational therapy, performing arts, occupational and industrial



training, the design of medical assistive devices, and human factors. Courses in motor learning and control, which were historically and are still housed almost exclusively in departments of kinesiology, must serve the needs and goals of a diverse student body. Indeed, kinesiology has become, in the twenty-first century, a major of choice as a gateway field for students preparing in widely diverse career fields.

This wide diversity of scholarly perspectives and career options related to the study of skilled human movement means that a textbook must cover a broad terrain of both theory and application. Traversing that broad terrain is another major goal of the current text. After introducing the basic perceptual and neurological foundations necessary for studying motor learning and control intelligently, the two major contemporary theories applied to the study and understanding of motor skills, cognitively based information processing theories and dynamical systems theories, are presented. Throughout the book, the attempt has been to show how each theory offers advantages and insights into our knowledge of how people control and learn movement skills. Indeed, this book takes the position that both theoretical approaches have much to offer and that in matters of discerning good instructional applications we can learn much from both. In terms of theoretical accuracy, I have constantly attempted to provide a fair presentation and evaluation of both theories, pointing to the values inherent in each, as well as the areas of possible inadequacies needing further development in each.

Beyond the specifics of neurological findings or theoretical assumptions, chapters present examples of research investigations related to the topics presented. The intent here is to demonstrate that much, if not most, of what we do know about effective principles and techniques for instructing motor skills is based upon sound empirical research, even when disagreements may exist over the underlying mechanisms and theoretical assumptions supporting those practical findings.

This book, then, is aimed at providing a comprehensive, authoritative, and engaging overview of the major areas of study in motor learning and control from a broadly encompassing theoretical and scholarly perspective. Its intended audience includes students preparing in any of the diverse career fields in which skillful human movement is an essential component. The text is specifically designed for use in an upper-division undergraduate or beginning graduate course in motor learning and control, and assumes some basic college-level background in human anatomy and physiology.

Finally, it is hoped that this book also serves a more general purpose in highlighting the significance of movement skills in every facet of human life, and helps initiate readers into a lifelong appreciation for the importance and wonder of skillful human actions.

## ORGANIZATION OF THE TEXT

This book is organized into 12 chapters. The first two chapters are designed to introduce the field of study covered in the text. Chapter 1 introduces and defines the two disciplines motor learning and motor control, and discusses

why it is essential they be studied together when application is a major interest. The chapter also presents a brief history of these two disciplines, identifies their relevance and applicability in a number of career fields, and finishes with a section concerning why the study of motor learning and control is important for students in these movement-related career fields. Chapter 2 introduces the subject matter of the text: human motor skills. The essential characteristics of motor skills are identified and thoroughly discussed, and the major problems confronting researchers and theorists studying motor skills are presented. Methods for classifying motor skills are also presented in this chapter. Together, these two chapters circumscribe the area of study for the text, establish the problems and areas of concern for movement scientists in the area, and relate the field of study to areas of personal and career interests among readers.

After introducing the field of study, the remainder of the book is organized around three groupings of chapters that, if viewed as a progressive series of topics, represent the book's subtitle: "From Theory to Practice." Chapters 3 and 4 present the neurological and theoretical underpinnings of contemporary motor learning and control. Chapter 3 is concerned with relating information on the perceptual and neurological activities and structures of the central nervous system. It conveys a solid understanding of the workings of the motor system in controlling human movement, as well as the changes that occur over the course of learning. Chapter 4 follows with a thorough presentation of the two major contemporary theories of motor learning and control, namely cognitive-based theories focusing on information processing approaches such as schema theory, and dynamical systems approaches focusing on the constructs of constraints, attraction, self-organization, and emergence. Also presented in this chapter is a discussion of the work of Nikolai Bernstein, whose ideas of synergies and learning progressions in many ways form an intellectual bridge between cognitive based information processing and dynamical systems approaches.

Chapters 5 through 8 are aimed at providing a comprehensive introduction to the foundations of learning. Chapter 5 discusses the basic laws and fundamental principles of learning, such as performance curves, the Law of Practice, the asymptotic nature of learning, and the transfer of learning. The chapter also presents a discussion and example of how learning is assessed using acquisition, retention, and transfer measures, and explicitly presents and discusses the distinction between performance and learning, which is carried forward as a major theme throughout the remainder of the text. Chapter 6 presents a discussion of the role of memory in learning. Although most of the work in memory research has been conducted from cognitive-based theoretical models and is covered as such, the chapter also gives due consideration to the concepts of affordances and attunement as prescribed by ecological psychological approaches within dynamical systems models. Chapter 7 discusses the stages of learning. Presented here are the three-stage models of Fitts and Posner representing cognitive-based information processing models, and the more recent model by Vereijken et al., developed from dynamical systems theory. The concept of expertise and high-level performance is also presented and discussed in this chapter. Chapter 8 is concerned with individual differences in motor skill capabilities and discusses the factors responsible for differences in how people acquire and perform motor skills.

The final four chapters of the book complete the progression from theory to practice by focusing on the practice experience. By this time students should possess a solid basis for understanding the implications of theory for practice design. A premise of this book is that practice understood in the context of theory and fundamental principles of learning is a prerequisite to both comprehensive understanding and effective application of practice strategies and techniques. Chapter 9 presents pre-practice considerations concerning motivation and attention, providing techniques for optimizing both among learners. Chapter 10 presents an overview of contemporary findings and thinking related to the provision of verbal instructions and visual demonstrations, both practical areas having undergone considerable rethinking in light of contemporary research findings. Chapter 11 then discusses a number of factors involved in the design of practice experiences, including the scheduling of practice when teaching both a single skill and several skills within a practice session, the distribution or spacing of practice both within and between practice sessions, and part-practice techniques and their appropriate uses. Chapter 12 concludes the chapters on practice with a presentation of the important topic of feedback, including the uses, roles, and strategies for providing effective feedback.

Finally, an appendix is provided covering aspects of laboratory research and the preparation of written laboratory or research reports. This information is provided in appendixes for classes in which laboratory experiences are included, or in which instructors wish to include additional information concerning research techniques and practices.

## PEDAGOGICAL FEATURES

A number of features have been added to chapters to aid student learning. A pedagogical approach, based on considerable research support, that students learn best when a text requires constant self-examination and application of content material, was a guiding principle in the preparation and writing of this book. By engaging student interest, critical reflection, and thoughtful application of the materials presented, the text aims to deepen both content knowledge and the students' critical thinking and decision-making abilities related to the control and learning of motor skills.

Figures and tables illustrating textual content have been included wherever necessary and helpful in clarifying chapter topics.

As a special feature of the text, boxes within chapters have been provided to add additional information expanding upon that in the text. These are often in the form of real-life examples in which textual content is applied in actual situations. Other boxes present exercises for students to test their understanding of topics, as well as to develop skills in applying chapter content in movement-related contexts. Boxes help carry students through the chapters by providing constant reinforcement of main topical ideas through real-life examples, professional applications, and personal applications designed to enhance both student interest and learning of the chapter content.



At the conclusion of each chapter are several pedagogical features designed to help students evaluate their grasp of chapter content, provide additional learning experiences, and serve as resources for further study and preparation for course evaluations.

Immediately following the chapter summaries are several Learning Exercises. These exercises include critical analyses and application exercises in which chapter topics must be used to solve professional and movement-skill problems, as well as field observations. The field observations include both interview and observational analyses. In these later examples, students are asked to observe various skill performance situations, collect data, perform critical analyses and draw conclusions, and summarize their findings in written reports. Several exercises covering various areas of concern with varying degrees of complexity, as well as both critical thinking and field analysis exercises, are included for each chapter. These Learning Exercises may be used in a variety of different ways, including as individual assignments, group assignments, class projects, formal laboratory exercises, and additional evaluative tools. Instructors may also find many of the Learning Exercises suited for class assignment and discussion, and might well build some lectures around these projects. As with many of the previous aspects of the text, these exercises are designed expressly to involve students more completely in their own learning.

The For Further Study section begins with a short multiple-choice and completion quiz, testing students' knowledge of the chapter and helping them identify possible areas in need of reevaluation or additional study.

The section Study Questions, as the name implies, lists a number of questions around which students might organize their review and study of the chapter; taken as a whole, the Study Questions offer a thorough overview of the major areas covered within a chapter.

The For Further Study section ends with suggestions for further reading relative to the topics presented within the chapter. All of the suggested readings are from readily available sources, so course instructors can make them available though their respective college and university libraries if desired.

## **INSTRUCTOR RESOURCES**

**PowerLecture DVD-ROM:** This one-stop course preparation and presentation resource makes it easy for instructors to assemble, edit, publish, and present custom lectures for your course, using PowerPoint. The PowerLecture DVD-ROM includes PowerPoint slides with all art and tables from the book, the Instructor's Manual, the test bank, and videos.

**Test Bank:** The test bank features an assortment of over 400 multiple-choice, completion, and short answer essay questions. The Test Bank is included on the PowerLecture DVD.

**Instructor's Manual:** Authored by William Edwards, this comprehensive manual includes chapter objectives, annotated lecture presentation outlines, and classroom activity suggestions. The Instructor's Manual is found on the PowerLecture DVD.

## STUDENT RESOURCES

**CourseMate:** The CourseMate brings course concepts to life with interactive learning, study, and exam preparation tools that support the printed textbook. The CourseMate includes an interactive eBook, interactive teaching and learning tools including quizzes, flashcards, videos, and more. It also contains the Engagement Tracker, a first-of-its-kind tool that monitors student engagement in the course.

## ACKNOWLEDGMENTS

Although many people have contributed to this text in ways probably both they and I do not realize or have long forgotten—including my fourth-grade teacher Mrs. LaDue, who made me write essays even when I complained that I was incapable of it and had no reason for learning to do so at any rate, and then both ruthlessly corrected and profusely praised my efforts when I did produce the required paper—there are still a few people that I must identify for special acknowledgment.

No academic should forget those special men and women who taught him and whose teachings, belief in his abilities, and encouragement initiated him into the world of scholarship and academe. I was fortunate to have had several such mentors. These include Art Ridgeway and Lynn Emery at California State Polytechnic University, and Roger Burke, J. Tillman Hall, Earl Pullias, and Ruth Sparhawk at the University of Southern California. Each, in his or her own way, encouraged, inspired, and shaped my academic and professional interests and development. This book hopefully reflects some of the many lessons that they passed on to me.

Rob Carlson, who was my department chair at San Diego State University (now Dean at California State University, San Bernardino), was instrumental in his support at a critical time in my early professional years. Without his professional support and generosity, this book, and possibly the career that spawned it, may never have taken form.

My colleagues and students at California State University, Sacramento, have provided many opportunities for both reflection and development of the ideas in this book. From my students, I have learned that teaching most profitably moves in two directions, from teacher to students and from students to teacher, if an instructor allows. Especially for my motor learning students who used earlier drafts of this book as their class text, and whose interest and many suggestions contributed to its development (and the idea for the cover), I am appreciative.

The good folks at Cengage Learning and their publishing auxiliaries have been a joy to work with and have always displayed high professional expertise in rendering this text in its final form. I must mention especially Nedah Rose, senior development editor at Cengage Learning, who has been the best, and certainly most patient, editor for whom any writer could ask. This book would not have taken initial shape, nor have come to ultimate fruition, without her belief in it.

Finally, I am most grateful for the opportunity to acknowledge the significant contributions of my wife, Barbara Edwards, to the development of this work. She read, reread, edited, and reread again every word in these chapters many times over. Her suggestions for changes in wording and content have significantly contributed to the clarity and usefulness of the text. Her many late nights editing my latest draft before I sent it off to the publisher the following morning deserve an A+ in spousal support. Of course, my greatest support has come, as always, from her love, encouragement, and constant faith shared in our “cord of three.” It is to her that this book is dedicated.

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