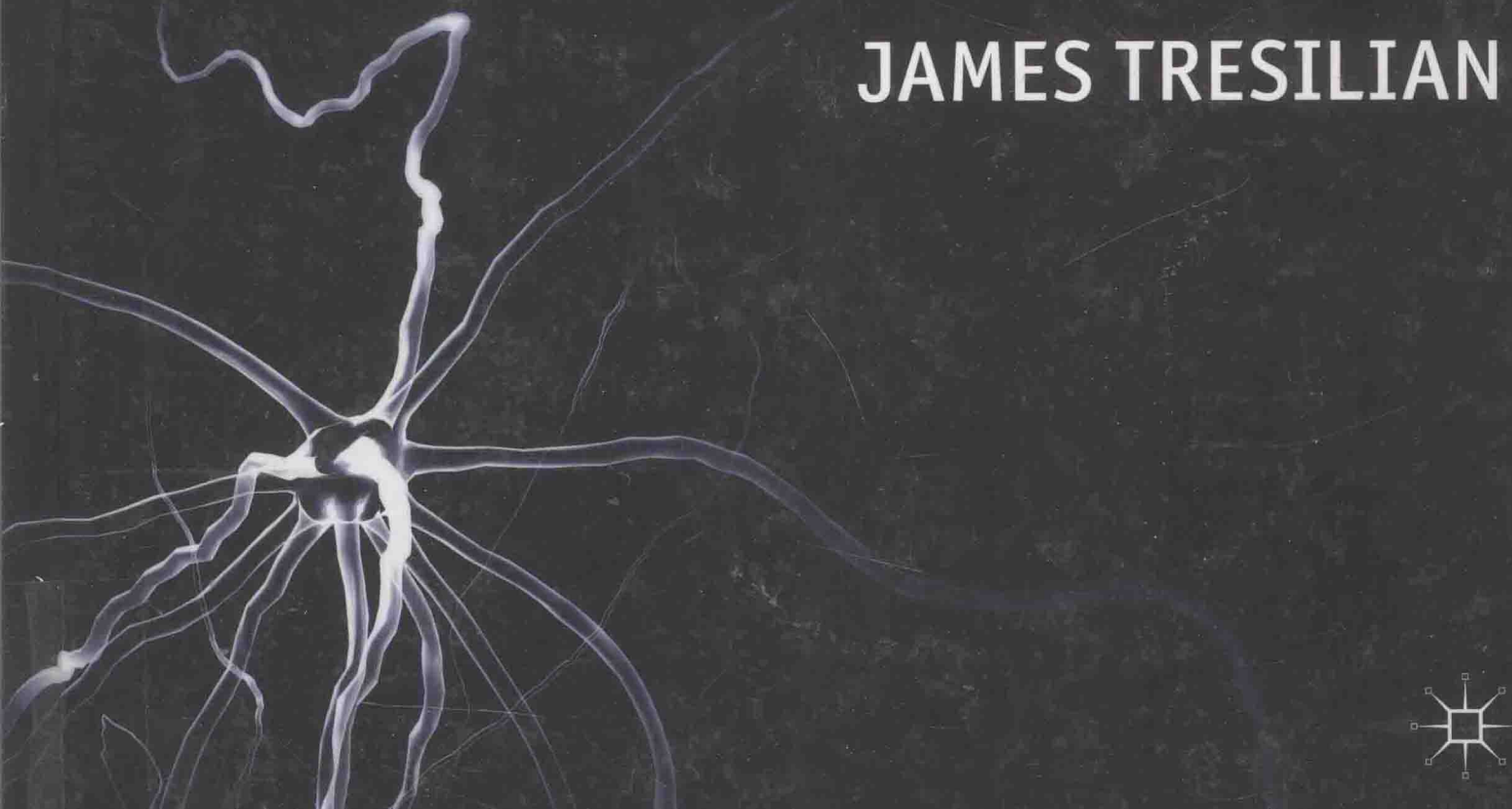




SENSORIMOTOR CONTROL & LEARNING

An Introduction to the Behavioral Neuroscience of Action

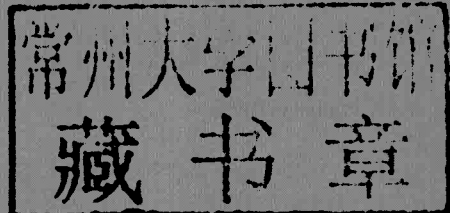
JAMES TRESILIAN



Sensorimotor Control and Learning

An introduction to the
behavioral neuroscience
of action

James Tresilian
University of Warwick



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In memory of my father

Preface

*Everyone said that it couldn't be done,
But he, with a grin, replied
That he'd never be one to say it couldn't be done
Leastways, not 'til he'd tried.
So he buckled right in with that same little grin,
By Golly! He went right to it,
He tackled the thing that couldn't be done
And he, um ...
... couldn't do it.*

Anon¹

This book provides a tutorial introduction to sensorimotor behavior and learning. It is written to be used as a primary text for teaching at the upper undergraduate and beginning graduate levels in kinesiology and psychology. The breadth and depth of coverage is likely to make it useful to research students and to undergraduates in other disciplines such as human factors, biomedical engineering, physiotherapy, and the neurosciences. I have made an effort to use real-world examples throughout; I have not attempted to cover applications. There are many texts that emphasize applications in physical education and sports (e.g., Edwards, 2010; Magill, 2010; Schmidt and Lee, 2011), ergonomics and human factors engineering (e.g., Wickens *et al.*, 2003), and movement therapy and rehabilitation (e.g., Shumway-Cook and Woollacott, 2011); this book is not intended to be an alternative to these. Its purpose is to provide an advanced-level introduction to the scientific study and understanding of sensorimotor behavior.

The book has a self-explanatory structure (see Contents) and is designed to support many different courses of study (I have never attempted to teach more than about four chapters' worth of material in any single-semester course). I have made the book as modular as possible so that it can be used in a flexible manner: the material has been used to support teaching at all levels of undergraduate study in the UK by judicious selection of sections and subsections. The material seems to have gone down surprisingly well with psychology students; the only negative comments have been occasional statements to the effect that 'this isn't psychology' and 'too much science'. Depending upon one's point of view, comments of this sort are not necessarily bad.

The original idea was to present a comprehensive, up-to-date, balanced, and accessible introduction to the field. I hope that what I have managed to produce is balanced, accessible, and up-to-date. I freely confess, however, that it is not comprehensive. I, um ... couldn't do it: there weren't enough hours in the day or days in the week, and no sensible publisher could have justified production of a book with the number of words and figures that would have been needed. If anyone doubts my claim that there weren't enough hours in the day, consider the following. The book has about 650 numbered figures, many with multiple diagrams. In

¹ This is a parody of a poem by Edgar Guest as recounted to me by my father when I was a small boy. The original may be found in Guest (1947).

fact, there are more than 1000 individual diagrams all drawn by the author. The average time taken to prepare a diagram (including captions and labelling) was about 2 hours, which makes a total of a little over 2000 hours or 50 weeks of full time work (5 days a week, 9 am to 5 pm). This had to come from the author's spare time (I have a full-time job), which gives an idea of the magnitude of the task. The result is that the book has numerous sins of omission, some of which I was very reluctant to commit. The treatment of learning is particularly thin: I have only been able to scrape the surface of the vast literature relevant to sensorimotor learning and memory. My decisions concerning what to cover and what to leave out were guided by:

- (1) The courses I teach and have taught.
- (2) My interests (which are narrow) and my prejudices (which range widely).
- (3) What is most commonly taught in courses on motor control and learning. Different people teach different topics, of course, and different textbooks cover different material. I looked at the latest editions of existing textbooks and at course outlines from various universities around the world to determine the most frequent topics.
- (4) Accessibility: the research literature in sensorimotor control and learning is replete with models and methods that involve the use of advanced mathematical techniques and/or complex concepts from engineering and physics. In my experience, the average undergraduate student of kinesiology or psychology lacks the background necessary to be able to gain any useful understanding of these techniques and concepts without studying them formally. Intuitive presentations of the simpler ideas is important, but I remain to be persuaded that this is true for many of the more advanced and complex ideas. Intuitive descriptions of dynamical systems theory, for example, have a tendency to befuddle the reader, or worse, imbue them with the illusion of understanding². Thus, I have not attempted to provide intuitive discussions of more complex mathematical ideas.

If, as a result of my decisions, I have left out your favorite topic, theory, or experiment, then I can only apologize. Please feel free to write to me with a request that it be included in the next edition (but beware, there may never be one).

JAMES TRESILIAN

² A more rigorous approach would be to start with a book like Blanchard, Devaney, Hall (2011).

Author's acknowledgments

My thanks to the many reviewers (all anonymous with the exception of Florian Kagerer) who took the time to make helpful and encouraging comments, either on selected chapters or on the text as a whole. I acted on almost all suggestions for improvement, with the exception of one or two with which I disagreed. Unfortunately, I was forced to ignore most of the requests for additional content – I simply didn't have enough time or space to squeeze anything more in.

Thanks to Richard Carson and Mark Mon-Williams for encouraging me to persevere with this project, to Jaime Marshall at Palgrave Macmillan for his relentless but good-humored insistence that I get on with it, to Anna Plooy for pedagogical advice and helpful tips for drawing in Word, and to Friedericke Schlaghecken for welcome doses of common sense and coffee. I lay the blame for my interest in the lambda equilibrium point hypothesis (described at length in Chapter 6) on Randy Flanagan, though he may disagree with my continuing conviction that it is a valuable (if misunderstood) contribution to our understanding of neuromuscular control.

The hard work of Aléta Bezuidenhout and her team on the book's design is greatly appreciated. With one or two exceptions, I drew the diagrams using Word drawing tools. Some are based on figures from elsewhere; in such cases I have acknowledged sources, and I sought permission from copyright holders when that seemed necessary. I hope that cases where it didn't seem necessary are similarly interpreted by the relevant copyright holders and their teams of ruthless, high-powered lawyers. Last, but not least, my heartfelt thanks to Nico – who had to put up with a lot, bore it stoically and never ceased to be encouraging (perhaps because she thought that would be the quickest way to bring the ghastly torment to an end!) – and to Thomas, who also had to put up with a lot (but luckily for me he won't remember a thing about it).

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