

The Cambridge Handbook of Expertise and Expert Performance

Second Edition

In this updated and expanded edition of *The Cambridge Handbook of Expertise and Expert Performance*, some of the world's foremost experts on expertise share their scientific knowledge of expertise and expert performance and show how experts may differ from non-experts in terms of development, training, reasoning, knowledge, and social support. The book reviews innovative methods for measuring experts' knowledge and performance in relevant tasks. Sixteen major domains of expertise are covered, including sports, music, medicine, business, writing, and drawing, with leading researchers summarizing their knowledge about the structure and acquisition of expert skills and knowledge, and discussing future prospects. General issues that cut across most domains are reviewed in chapters on various aspects of expertise, such as general and practical intelligence, differences in brain activity, self-regulated learning, deliberate practice, aging, knowledge management, and creativity.

K. ANDERS ERICSSON is currently the Conradi Eminent Scholar and Professor of Psychology at Florida State University. He is also a Fellow of the Center for Advanced Study in the Behavioral Sciences, the American Psychological Association, the Association for Psychological Science, and a member of the Royal Swedish Academy of Engineering Sciences. His research has been featured in cover stories in *Scientific American*, *Time*, *Fortune*, the *Wall Street Journal*, and the *New York Times*. He has been invited to give keynote presentations at conferences of surgeons, musicians, teachers, clinical psychologists, athletes, and coaches as well as professional sports organizations, such as the Philadelphia Eagles, the San Antonio Spurs, the Toronto Blue Jays, and Manchester City Football Club.

ROBERT R. HOFFMAN is a recognized world leader in cognitive systems engineering and human-centered computing. Currently he is senior research scientist at the Institute for Human and Machine Cognition in Pensacola, FL. He is a fellow of the Association for Psychological Science, fellow of the Human Factors and Ergonomics Society, senior member of the Association for the Advancement of Artificial Intelligence, and a Fulbright scholar. His PhD is in experimental psychology from the University of Cincinnati. His Postdoctoral Associateship was at the Center for Research on Human Learning at the University of Minnesota. He also served on the faculty of the Institute for Advanced Psychological Studies at Adelphi University. Hoffman has been recognized internationally in psychology, remote sensing, human factors engineering, intelligence analysis, weather forecasting, and artificial intelligence – for his research on the psychology of expertise, the

methodology of cognitive task analysis, HCC issues for intelligent systems technology, and the design of macrocognitive work systems.

AARON KOZBELT is Professor of Psychology at Brooklyn College and the Graduate Center of the City University of New York. His research focuses on creativity and cognition in the fine arts, with an emphasis on perception in visual artists, lifespan creativity in composers, and evolutionary aspects of aesthetics and creativity. He has published more than 80 peer-reviewed articles and book chapters, and his research has been funded by the National Science Foundation. He serves on several editorial boards and has received several national and international awards for his research, including the Daniel Berlyne Award from Division 10 of the American Psychological Association and the Alexander Gottlieb Baumgarten Award from the International Association of Empirical Aesthetics.

A. MARK WILLIAMS is Professor and Chair of the Department of Health, Kinesiology, and Recreation at the University of Utah. He is a fellow of the British Psychological Society, the British Association of Sport and Exercise Science, the National Academy of Kinesiology, and the European College of Sports Science. His research interests focus on the neural and psychological mechanisms underpinning the acquisition and development of perceptual-cognitive and perceptual-motor skills. He has published over 300 journal articles and book chapters, and has written or edited 15 books. He is Editor-in-Chief for the *Journal of Sports Science* and sits on the editorial boards of several prominent journals. His research has been funded by research councils in Australia and the UK, by industrial partners such as Nike, and by several professional sports teams and national and international governing bodies.

The Cambridge Handbook of Expertise and Expert Performance

Second Edition

Edited by

K. Anders Ericsson

Florida State University

Robert R. Hoffman

Institute for Human and Machine Cognition

Aaron Kozbelt

Brooklyn College, City University of New York

A. Mark Williams

University of Utah

Cambridge University Press
978-1-107-13755-4 — The Cambridge Handbook of Expertise and Expert Performance
Edited by K. Anders Ericsson , Robert R. Hoffman , Aaron Kozbelt , A. Mark Williams
Frontmatter
[More Information](#)

CAMBRIDGE UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom
One Liberty Plaza, 20th Floor, New York, NY 10006, USA
477 Williamstown Road, Port Melbourne, VIC 3207, Australia
314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre, New Delhi – 110025, India
79 Anson Road, #06–04/06, Singapore 079906

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning, and research at the highest international levels of excellence.

www.cambridge.org

Information on this title: www.cambridge.org/9781107137554

DOI: 10.1017/9781316480748

© Cambridge University Press 2006, 2018

This publication is in copyright. Subject to statutory exception and to the provisions of relevant collective licensing agreements, no reproduction of any part may take place without the written permission of Cambridge University Press.

First published 2006

11th reprint 2013

Second edition 2018

Printed in the United States of America by Sheridan Books, Inc.

A catalogue record for this publication is available from the British Library.

ISBN 978-1-107-13755-4 Hardback

ISBN 978-1-316-50261-7 Paperback

Cambridge University Press has no responsibility for the persistence or accuracy of URLs for external or third-party internet websites referred to in this publication and does not guarantee that any content on such websites is, or will remain, accurate or appropriate.

Contents

<i>Notes on Contributors</i>	page ix
<i>Acknowledgments</i>	xiv

Part I Introduction and Perspectives

1	An Introduction to the Second Edition of <i>The Cambridge Handbook of Expertise and Expert Performance</i> : Its Development, Organization, and Content	3
	K. ANDERS ERICSSON	
2	A Sociological/Philosophical Perspective on Expertise: The Acquisition of Expertise through Socialization	21
	HARRY COLLINS AND ROBERT EVANS	
3	Reframing Expertise and its Development: A Lifeworld Perspective	33
	GLORIA DALL'ALBA	
4	The Evolution of Expertise	40
	BO WINEGARD, BENJAMIN WINEGARD, AND DAVID C. GEARY	
5	Expertise in Other Animals: Canines as an Example	49
	WILLIAM S. HELTON AND NICOLE D. HELTON	

Part II Overview of Approaches to the Study of Expertise: Brief Historical Accounts of Theories and Methods

6	Studies of Expertise from Psychological Perspectives: Historical Foundations and Recurrent Themes	59
	PAUL J. FELTOVICH, MICHAEL J. PRIETULA, AND K. ANDERS ERICSSON	
7	Expert Systems: A Perspective from Computer Science	84
	BRUCE G. BUCHANAN, RANDALL DAVIS, REID G. SMITH, AND EDWARD A. FEIGENBAUM	
8	Developing Occupational Expertise through Everyday Work Activities and Interactions	105
	STEPHEN BILLET, CHRISTIAN HARTEIS, AND HANS GRUBER	
9	Professionalism, Science, and Expert Roles: A Social Perspective	127
	HARALD A. MIEG AND JULIA EVETTS	

Part III Methods for Studying the Structure of Expertise

- | | | |
|----|--|-----|
| 10 | Perception in Expertise
DAVID LANDY | 151 |
| 11 | Eliciting and Representing the Knowledge of Experts
GAVAN LINTERN, BRIAN MOON, GARY KLEIN, AND
ROBERT R. HOFFMAN | 165 |
| 12 | Capturing Expert Thought with Protocol Analysis: Concurrent
Verbalizations of Thinking during Experts' Performance on
Representative Tasks
K. ANDERS ERICSSON | 192 |
| 13 | Methods for Studying the Structure of Expertise: Psychometric
Approaches
PHILIP L. ACKERMAN AND MARGARET E. BEIER | 213 |
| 14 | Studies of the Activation and Structural Changes of the Brain
Associated with Expertise
MERIM BILALIĆ AND GUILLERMO CAMPITELLI | 233 |

Part IV Methods for Studying the Acquisition and Maintenance of Expertise

- | | | |
|----|---|-----|
| 15 | Collecting and Assessing Practice Activity Data: Concurrent,
Retrospective, and Longitudinal Approaches
JOSEPH BAKER, NICOLA J. HODGES, AND MELISSA J. WILSON | 257 |
| 16 | Multidisciplinary Longitudinal Studies: A Perspective from the Field
of Sports
MARIJE T. ELFERINK-GEMSER, SANNE C. M. TE WIERIKE, AND CHRIS
VISSCHER | 271 |
| 17 | Using Cases to Understand Expert Performance: Method and
Methodological Triangulation
MICHAEL D. MUMFORD, TRISTAN MCINTOSH, AND TYLER MULHEARN | 291 |
| 18 | Historiometric Methods
DEAN KEITH SIMONTON | 310 |

Part V.I Domains of Expertise: Professions

- | | | |
|----|---|-----|
| 19 | Expertise in Medicine and Surgery
GEOFFREY R. NORMAN, LAWRENCE E. M. GRIERSON, JONATHAN
SHERBINO, STANLEY J. HAMSTRA, HENK G. SCHMIDT, AND SILVIA
MAMEDE | 331 |
| 20 | Expertise and Transportation
FRANCIS T. DURSO, ANDREW R. DATTEL, AND VLAD L. POP | 356 |

	Contents	vii
21 Expertise in Professional Design NIGEL CROSS		372
22 Toward Deliberate Practice in the Development of Entrepreneurial Expertise: The Anatomy of the Effectual Ask NICHOLAS DEW, ANUSHA RAMESH, STUART READ, AND SARAS D. SARASVATHY		389
23 Professional Writing Expertise RONALD T. KELLOGG		413
24 Expertise and Expert Performance in Teaching JAMES W. STIGLER AND KEVIN F. MILLER		431
25 Expert Professional Judgments and “Naturalistic Decision Making” KATHLEEN MOSIER, UTE FISCHER, ROBERT R. HOFFMAN, AND GARY KLEIN		453
26 Skilled Decision Theory: From Intelligence to Numeracy and Expertise EDWARD T. COKELY, ADAM FELTZ, SAIMA GHAZAL, JINAN N. ALLAN, DAFINA PETROVA, AND ROCIO GARCIA-RETAMERO		476
27 What Makes an Expert Team? A Decade of Research SHIRLEY C. SONESH, CHRISTINA LACERENZA, SHANNON MARLOW, AND EDUARDO SALAS		506
Part V.II Domains of Expertise: Arts, Sports, Games, and Other Skills		
28 Expertise in Music ANDREAS C. LEHMANN, HANS GRUBER, AND REINHARD KOPIEZ		535
29 Brain Changes Associated with Acquisition of Musical Expertise ECKART ALTENMÜLLER AND SHINICHI FURUYA		550
30 Expertise in Drawing AARON KOZBELT AND JUSTIN OSTROFSKY		576
31 Expertise in Chess FERNAND GOBET AND NEIL CHARNES		597
32 Mathematical Expertise BRIAN BUTTERWORTH		616
33 Expertise in Second Language Vocabulary MARIJANA MACIS, MÉLODIE GARNIER, LAURA VILKAITĖ, AND NORBERT SCHMITT		634
34 Expertise in Sport: Specificity, Plasticity, and Adaptability in High-Performance Athletes A. MARK WILLIAMS, PAUL R. FORD, NICOLA J. HODGES, AND PAUL WARD		653

Part VI Generalizable Mechanisms Mediating Types of Expertise

- | | | |
|----|--|-----|
| 35 | Superior Anticipation
BRUCE ABERNETHY, DAMIAN FARROW, AND DAVID L. MANN | 677 |
| 36 | Superior Working Memory in Experts
K. ANDERS ERICSSON | 696 |
| 37 | Expertise and Situation Awareness
MICA R. ENDSLEY | 714 |

Part VII General Issues and Theoretical Frameworks

- | | | |
|----|--|-----|
| 38 | The Differential Influence of Experience, Practice, and Deliberate Practice on the Development of Superior Individual Performance of Experts
K. ANDERS ERICSSON | 745 |
| 39 | Practical Intelligence and Tacit Knowledge: An Ecological View of Expertise
ANNA T. CIANCIOLO AND ROBERT J. STERNBERG | 770 |
| 40 | Cognitive Load and Expertise Reversal
SLAVA KALYUGA AND JOHN SWELLER | 793 |
| 41 | Expertise and Structured Imagination in Creative Thinking: Reconsideration of an Old Question
ROBERT W. WEISBERG | 812 |
| 42 | Aging and Expertise
RALF T. KRAMPE AND NEIL CHARNESS | 835 |
| | <i>Index of Subjects</i> | 857 |

Notes on Contributors

BRUCE ABERNETHY, School of Human Movement & Nutrition Sciences, The University of Queensland, Australia

PHILIP L. ACKERMAN, School of Psychology, Georgia Institute of Technology, Georgia

JINAN N. ALLAN, National Institute for Risk & Resilience, and Department of Psychology, University of Oklahoma, Oklahoma

ECKART ALTENMÜLLER, Institute of Music Physiology and Musicians' Medicine, University of Music, Drama and Media, Hanover, Germany

JOSEPH BAKER, School of Kinesiology and Health Science, York University, Canada

MARGARET E. BEIER, Department of Psychology, Rice University, Texas

MERIM BILALIĆ, Department of Psychology, University of Northumbria at Newcastle, UK

STEPHEN BILLETT, School of Education and Professional Studies, Griffith University, Australia

BRUCE G. BUCHANAN, Computer Science Department, University of Pittsburgh, Pennsylvania

BRIAN BUTTERWORTH, Institute of Cognitive Neuroscience, University College London, UK

GUILLERMO CAMPITELLI, School of Arts and Humanities, Edith Cowan University, Australia

NEIL CHARNESS, Department of Psychology, Florida State University, Florida

ANNA T. CIANCIOLO, School of Medicine, Southern Illinois University, Illinois

EDWARD T. COKELY, National Institute for Risk & Resilience, and Department of Psychology, University of Oklahoma, Oklahoma, and Max Planck Institute for Human Development, Germany

HARRY COLLINS, School of Social Sciences, Cardiff University, UK

NIGEL CROSS, Faculty of Science, Technology, Engineering & Mathematics, The Open University, UK

GLORIA DALL'ALBA, School of Education, The University of Queensland, Australia

ANDREW R. DATTEL, College of Aviation, Embry-Riddle Aeronautical University, Florida

RANDALL DAVIS, Computer Science and Artificial Intelligence Laboratory, Massachusetts Institute of Technology, Massachusetts

NICHOLAS DEW, Graduate School of Business and Public Policy, Naval Postgraduate School, California

FRANCIS T. DURSO, School of Psychology, Georgia Institute of Technology, Georgia

MARIJE T. ELFERINK-GEMSER, Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, The Netherlands

MICA R. ENDSLEY, SA Technologies, Inc., Arizona

K. ANDERS ERICSSON, Department of Psychology, Florida State University, Florida

ROBERT EVANS, School of Social Sciences, Cardiff University, UK

JULIA EVETTS, School of Sociology and Social Policy, University of Nottingham, UK

DAMIAN FARROW, Institute for Sport, Exercise and Active Living, Victoria University, Australia

EDWARD A. FEIGENBAUM, Computer Science Department, Stanford University, California

PAUL J. FELTOVICH, Institute for Human and Machine Cognition, Florida

ADAM FELTZ, Department of Cognitive and Learning Sciences, Michigan Technological University, Michigan

UTE FISCHER, School of Literature, Media & Communication, Georgia Institute of Technology, Georgia

PAUL R. FORD, Centre for Sport and Exercise Science and Medicine, University of Brighton, UK

SHINICHI FURUYA, SONY Computer Science Laboratory, Tokyo, Japan

ROCIO GARCIA-RETAMERO, Department of Experimental Psychology, University of Granada, Spain, and Max Planck Institute for Human Development, Germany

MÉLODIE GARNIER, University of Cambridge, UK

DAVID C. GEARY, Department of Psychological Sciences, University of Missouri, Missouri

SAIMA GHAZAL, Institute of Applied Psychology, University of the Punjab, Pakistan

FERNAND GOBET, Department of Psychological Sciences, University of Liverpool, UK

LAWRENCE E. M. GRIERSON, Department of Family Medicine, McMaster University, Canada

HANS GRUBER, Department of Educational Science, University of Regensburg, Germany, and Faculty of Education, University of Turku, Finland

STANLEY J. HAMSTRA, Accreditation Council for Graduate Medical Education, Illinois

CHRISTIAN HARTEIS, Institute of Educational Science, University of Paderborn, Germany

NICOLE D. HELTON, Independent scholar, Virginia

WILLIAM S. HELTON, Department of Psychology, George Mason University, Virginia

NICOLA J. HODGES, School of Kinesiology, University of British Columbia, Canada

ROBERT R. HOFFMAN, Institute for Human and Machine Cognition, Florida

SLAVA KALYUGA, School of Education, University of New South Wales, Australia

RONALD T. KELLOGG, Department of Psychology, St. Louis University, Missouri

GARY KLEIN, MacroCognition LLC, District of Columbia

REINHARD KOPIEZ, Hochschule für Musik, Theater und Medien, Germany

AARON KOZBELT, Department of Psychology, Brooklyn College of the City University of New York, New York

RALF T. KRAMPE, Brain & Cognition Laboratory, University of Leuven, Belgium

CHRISTINA LACERENZA, Leeds School of Business, University of Colorado, Boulder, Colorado

DAVID LANDY, Department of Psychological and Brain Sciences, Indiana University, Indiana

ANDREAS C. LEHMANN, Hochschule für Musik Würzburg, Germany

GAVAN LINTERN, Accident Research Centre, Monash University, Australia

MARIJANA MACIS, Manchester Metropolitan University, UK

SILVIA MAMEDE, Graduate School of Social Sciences and the Humanities, Erasmus University, Rotterdam, The Netherlands

DAVID L. MANN, Department of Human Movement Sciences, Vrije Universiteit Amsterdam, The Netherlands

SHANNON MARLOW, Department of Psychology, Rice University, Texas

TRISTAN MCINTOSH, Department of Psychology, University of Oklahoma, Oklahoma

HARALD A. MIEG, Geography Department, Humboldt-Universität zu Berlin, Germany

KEVIN F. MILLER, School of Education, University of Michigan, Michigan

BRIAN MOON, Perigeon Technologies LLC, Virginia

KATHLEEN MOSIER, Department of Psychology, San Francisco State University, California

TYLER MULHEARN, Department of Psychology, University of Oklahoma, Oklahoma

MICHAEL D. MUMFORD, Center for Applied Social Research, and Department of Psychology, University of Oklahoma, Oklahoma

GEOFFREY R. NORMAN, Department of Health Research Methods, McMaster University, Canada

JUSTIN OSTROFSKY, School of Social and Behavioral Sciences, Stockton University, New Jersey

DAFINA PETROVA, Department of Experimental Psychology, University of Granada, Spain

VLAD L. POP, Georgia Tech Research Institute, Georgia

MICHAEL J. PRIETULA, Goizueta Business School, Emory University, Georgia

ANUSHA RAMESH, Darden School of Business Administration, University of Virginia, Virginia

STUART READ, Atkinson Graduate School of Management, Willamette University, Oregon

EDUARDO SALAS, Department of Psychology, Rice University, Texas

SARAS D. SARASVATHY, Darden Graduate School of Business Administration, University of Virginia, Virginia

HENK G. SCHMIDT, Department of Psychology, Erasmus University, Rotterdam, The Netherlands

NORBERT SCHMITT, School of English, University of Nottingham, UK

JONATHAN SHERBINO, Hamilton General Hospital, McMaster University, Canada

DEAN KEITH SIMONTON, Department of Psychology, University of California at Davis, California

REID G. SMITH, i2k Connect LLC, Texas

SHIRLEY C. SONESH, Sonnenschein Consulting LLC, Louisiana

ROBERT J. STERNBERG, College of Human Ecology, Cornell University, New York

JAMES W. STIGLER, Department of Psychology, University of California at Los Angeles, California

JOHN SWELLER, School of Education, University of New South Wales, Australia

SANNE C. M. TE WIERIKE, Sport Science Institute Groningen, The Netherlands

LAURA VILKAITĖ, Faculty of Philology, Vilnius University, Lithuania

CHRIS VISSCHER, Center for Human Movement Sciences, University Medical Center Groningen, University of Groningen, The Netherlands

PAUL WARD, School of Psychological Sciences, University of Northern Colorado, Colorado

ROBERT W. WEISBERG, Department of Psychology, Temple University, Pennsylvania

A. MARK WILLIAMS, Department of Health, Kinesiology, and Recreation, University of Utah, Utah

MELISSA J. WILSON, Paralympics New Zealand, New Zealand

BENJAMIN WINEGARD, Carroll College, Montana

BO WINEGARD, Department of Psychology, Florida State University, Florida

Acknowledgments

K. Anders Ericsson wants to gratefully acknowledge the financial support provided by the Conradi Eminent Scholar Endowment at the Florida State Foundation during the editing phase of the work on this new edition of the handbook.

Robert R. Hoffman would like to thank the Institute for Human and Machine Cognition for its support during the writing and editing process.

Aaron Kozbelt would like to acknowledge Brooklyn College of the City University of New York for support during the preparation of the handbook.

A. Mark Williams would like to thank the College of Health at the University of Utah for its support during the writing and editing process.