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The Cambridge Handbook of Intelligence and Cognitive Neuroscience

Can the brain be manipulated to enhance intelligence? The answer depends on neuroscience progress in understanding how intelligence arises from the interplay of gene expression and experience in the developing brain and how the mature brain processes information to solve complex reasoning problems. The bad news is the issues are nightmarishly complex. The good news is there is extraordinary progress from researchers around the world. This book is a comprehensive sampling of recent exciting results, especially from neuroimaging studies. Each chapter has minimum jargon, so an advanced technical background is not required to understand the issues, the data, or the interpretation of results. The prospects for future advances will whet the appetite of young researchers and fuel enthusiasm for researchers already working in these areas. Many intelligence researchers of the past dreamed about a day when neuroscience could be applied to understanding fundamental aspects of intelligence. As this book demonstrates, that day has arrived.

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"This exciting book makes an elegant case that human intelligence is not the result of a test. It is the consequence of a brain. Drawing on state-of-the-art imaging methods, the reader is afforded a comprehensive view of the substrates enabling our most valued mental abilities."

Scott T. Grafton, Bedrosian-Coyne Presidential Chair in Neuroscience and Director of the Brain Imaging Center, University of California at Santa Barbara

"Our scientific understanding of human intelligence has advanced greatly over the past decade in terms of the measurement and modeling of intelligence in the human brain. This book provides an excellent analysis of current findings and theories written by top international authors. It should be recommended to students and professionals working in this field."

Sarah E. MacPherson, Senior Lecturer in Human Cognitive Neuroscience, University of Edinburgh

"This handbook focuses on the brain, but also integrates genetics and cognition. Come for a comprehensive brain survey and get the bonus of a panoramic foreshadowing of integrated intelligence research and applications."

Douglas K. Detterman, Louis D. Beaumont University Professor Emeritus of Psychological Sciences, Case Western Reserve University

"This handbook captures the conceptualization and measurement of intelligence, which is one of psychology's greatest achievements. It shows how the advent of modern imaging techniques and large-scale data sets have added to our knowledge about brain–environmental–ability relationships and highlights the controversy in this rapidly expanding field."

Diane F. Halpern, Professor of Psychology, Emerita, Claremont McKenna College

"This handbook assembles an impressive group of pioneers and outstanding young researchers at the forefront of intelligence neuroscience. The chapters summarize the state of the field today and foreshadows what it might become."

Lars Penke, Professor of Psychology, Georg August University of Göttingen

"This book is a tribute to its topic. It is intelligently assembled, spanning all aspects of intelligence research and its applications. The authors are distinguished experts, masterfully summarizing the latest knowledge about intelligence obtained with cutting-edge methodology. If one wants to learn about intelligence, this is the book to read."

Yulia Kovas, Professor of Genetics and Psychology, Goldsmiths University of London

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For all those who inspire us – without reference to success or failure – to understand the origins of intelligence and the diversity of talents that make us all equally human.
And for Michelle, who inspires me, beyond compare.

Aron K. Barbey

To my son, Alexandre, who enriches my life.
To my father, Adel, who has taught me not to let the dictates of my passions interfere with my assessments of the facts and of the weight of evidence.
To the mentors that have shaped my career and approach to science.

Sherif Karama

Dedicated to all the scientists and students who follow intelligence data wherever they lead, especially into the vast uncharted recesses of the brain.

Richard J. Haier

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Preface

This book introduces one of the greatest and most exciting scientific challenges of our time – explicating the neurobiological foundations of human intelligence. Written for students and for professionals in related fields, *The Cambridge Handbook of Intelligence and Cognitive Neuroscience* surveys research emerging from the rapidly developing neuroscience literature on human intelligence. Our emphasis is on theoretical innovation and recent advances in the measurement, modeling, and characterization of the neurobiology, especially from brain imaging studies.

Scientific research on human intelligence is evolving from limitations of psychometric testing approaches to advanced neuroscience methods. Each chapter, written by experts, explains these developments in clear language. Together the chapters show how scientists are uncovering the rich constellation of brain elements and connections that give rise to the remarkable depth and complexity of human reasoning and personal expression. If you doubt that intelligence can be defined or measured sufficiently for scientific study, you are in for a surprise. Each chapter presents thought-provoking findings and conceptions to whet the appetite of students and researchers.

Part I is an introduction to fundamental issues in the characterization and measurement of general intelligence (Coyle, Chapter 1), reviewing emerging methods from network neuroscience (Hilger and Sporns, Chapter 2), presenting a comparative analysis of structural and functional MRI methods (Martínez and Colom, Chapter 3), and surveying multidisciplinary research consortia and large-scale data repositories for the study of general intelligence (Khundrakpam, Poline, and Evans, Chapter 4).

Part II reviews cognitive neuroscience theories of general intelligence, evaluating the weight of the neuroscience evidence (Euler and McKinney, Chapter 5), presenting an emerging approach from network neuroscience (Barbey, Chapter 6), and reviewing neuroscience research that investigates general intelligence within a developmental (Kievit and Simpson-Kent, Chapter 7) and lifespan framework (Hennessee and Park, Chapter 8), and that applies a social, cognitive, and affective neuroscience perspective (Ahrends, Vuust, and Kringelbach, Chapter 9). Due to a production issue, Chapter 23 (Vargas and Just) was omitted from Part II, where it was intended to appear. This chapter now appears as the final chapter.

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Part III provides a systematic review of contemporary neuroimaging methods for studying intelligence, including structural and diffusion-weighted MRI techniques (Genç and Fraenz, Chapter 10; Drakulich and Karama, Chapter 11), functional MRI methods (Basten and Fiebach, Chapter 12; Cohen and D'Esposito, Chapter 13), and spectroscopic imaging of metabolic markers of intelligence (Jung and Chohan, Chapter 14; Raz and Stanley, Chapter 15).

Part IV reviews predictive modeling approaches to the study of human intelligence, presenting research that enables the prediction of cognitive ability differences from brain imaging and genetics data (Anderson and Holmes, Chapter 16; Willoughby and Lee, Chapter 17).

Finally, Part V addresses the need to translate findings from this burgeoning literature into potential action/policy, presenting research on cognitive enhancement (Posner and Rothbart, Chapter 18), clinical translation (Cohen-Zimerman, Salvi, and Grafman, Chapter 19), and education and public policy (Asbury and Fields, Chapter 20; Sternberg, Chapter 21; Wai and Bailey, Chapter 22).

Research on cognitive neuroscience offers the profound possibility of enhancing intelligence, perhaps in combination with molecular biology, by manipulating genes and brain systems. Imagine what this might mean for education, life success, and for addressing fundamental social problems. You may even decide to pursue a career dedicated to these prospects. That would be an extra reward for us.

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