

Replacement of Neanderthals by Modern Humans Series

Emiliano Bruner
Naomichi Ogihara
Hiroki C. Tanabe *Editors*

Digital Endocasts

From Skulls to Brains

 Springer

Replacement of Neanderthals by Modern Humans Series

Edited by

Takeru Akazawa

Research Institute, Kochi University of Technology
Kochi 782-8502, Japan
akazawa.takeru@kochi-tech.ac.jp

Ofer Bar-Yosef

Department of Anthropology, Harvard University
Cambridge, Massachusetts 02138, USA
obaryos@fas.harvard.edu

The planned series of volumes will report the results of a major research project entitled “Replacement of Neanderthals by Modern Humans: Testing Evolutionary Models of Learning”, offering new perspectives on the process of replacement and on interactions between Neanderthals and modern humans and hence on the origins of prehistoric modern cultures. The projected volumes will present the diverse achievements of research activities, originally designed to implement the project’s strategy, in the fields of archaeology, paleoanthropology, cultural anthropology, population biology, earth sciences, developmental psychology, biomechanics, and neuroscience. Comprehensive research models will be used to integrate the discipline-specific research outcomes from those various perspectives. The series, aimed mainly at providing a set of multidisciplinary perspectives united under the overarching concept of learning strategies, will include monographs and edited collections of papers focusing on specific problems related to the goals of the project, employing a variety of approaches to the analysis of the newly acquired data sets.

Editorial Board

Stanley H. Ambrose (University of Illinois at Urbana-Champaign), **Kenichi Aoki** (Meiji University), **Emiliano Bruner** (Centro Nacional de Investigación Sobre la Evolución Humana), **Marcus W. Feldman** (Stanford University), **Barry S. Hewlett** (Washington State University), **Tasuku Kimura** (University of Tokyo), **Steven L. Kuhn** (University of Arizona), **Yoshihiro Nishiaki** (University of Tokyo), **Naomichi Oghihara** (Keio University), **Dietrich Stout** (Emory University), **Hiroki C. Tanabe** (Nagoya University), **Hideaki Terashima** (Kobe Gakuin University), **Minoru Yoneda** (University of Tokyo)

More information about this series at <http://www.springer.com/series/11816>

Emiliano Bruner • Naomichi Ogihara •
Hiroki C. Tanabe
Editors

Digital Endocasts

From Skulls to Brains

 Springer

Editors

Emiliano Bruner
CENIEH
Burgos, Spain

Naomichi Ogiwara
Keio University
Yokohama, Japan

Hiroki C. Tanabe
Nagoya University
Nagoya, Japan

Replacement of Neanderthals by Modern Humans Series
ISBN 978-4-431-56580-2 ISBN 978-4-431-56582-6 (eBook)
DOI 10.1007/978-4-431-56582-6

Library of Congress Control Number: 2017957848

© Springer Japan KK 2018

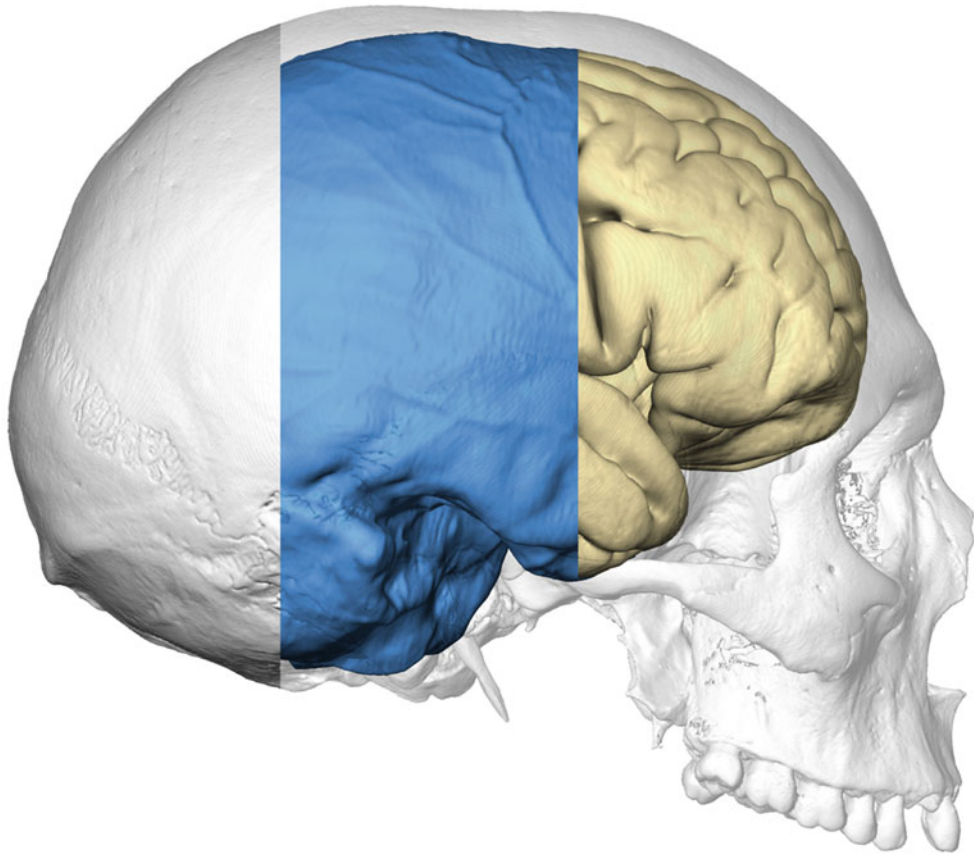
This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer Japan KK
The registered company address is: Chiyoda First Bldg. East, 8-1 Nishi-Kanda Chiyoda-ku, 101-0065 Tokyo, Japan



Brain, endocast, and skull digital reconstruction (courtesy of Simon Neubauer)

Preface



In recent years, computer-based techniques have led to a noticeable renaissance of most anatomical disciplines, involving new challenges and re-introducing old problems. Digital anatomy has represented a major advance in the visualization and exploration of anatomical elements, and computed morphometrics has supplied numerical and statistical tools for analyzing anatomical systems using proper quantitative approaches. Before this “pixel revolution,” anatomy was often limited by reduced sample sizes and by methodological difficulties associated with physical dissections. Working with bodies, most of all when dealing with humans, implies a limited availability of individuals, difficulties in management and administration, and large and complex histological preparations. Furthermore, dissections only allow the study of the anatomical components outside of their functional conditions. Digital tools can be used to investigate large samples with an extreme resolution and within their biological context, preventing most of those limitations, which, decades ago, contributed to a sort of “freezing” of the anatomical fields, slowing down their development and often impeding the efficient dissemination of their achievements. Once the computed tools had become available on a large scale and many forgotten topics had been recovered from past literature, we realized that we still lacked much information regarding our own anatomy. In fact, we have spent the last decades principally investigating molecules and microscopic features, but we do not yet have a robust knowledge of our bones and vessels. For many macroanatomical traits, we still ignore the variations, influences, and developmental processes that generate the phenotypic variability of our species. Importantly, some of these anatomical traits may be crucial not only from an evolutionary perspective, but also from a medical point of view.

Physical dissections and other non-digital approaches are still mandatory and essential, but the complementary potentialities of these computed methods are outstanding. Nonetheless, as usual, power must be accompanied by adequate control of its capacities and limitations. Most of these methods are based on very complex and complicated technical and numerical assumptions and criteria that rely on elaborate programs, devices, and algebraic transformations, and they are based on an important background integrating electronics, informatics, and statistics. Therefore, the entangled numerical elaboration associated with these digital models requires competence and caution. Frequently, programs are sufficiently “user-friendly” to allow a basic manipulation of the data without any comprehensive knowledge of the processes involved. This usability further increases the possibility of a superficial use, interpretation, or understanding, of the actual outputs of a computerized analysis. Multidisciplinarity is, indeed, strictly required in such a complicated methodological context.

Most anatomical disciplines have taken advantage of these methodological changes, but one that probably has been particularly privileged by these digital approaches is neuroscience. Structural and functional imaging has induced a considerable revolution in all kinds of brain studies, including evolutionary neuroanatomy. This book is part of the 5-year (2010–2014) project “Replacement of Neanderthals by Modern Humans: Testing Evolutionary Models of Learning” (RNMH), funded by the Japanese Government (Ministry of Education, Culture, Sports, Science, and Technology, Grant-in-Aid for Scientific Research on Innovative Areas No. 22101001) and coordinated by Professor Takeru Akazawa. The project is based on a multidisciplinary approach, integrating cultural anthropology, biological sciences, and engineering, to investigate and compare cognitive and cultural capacities in modern humans and Neanderthals, and to make inferences on their respective learning abilities. This new volume of the RNMH Series is dedicated to brain evolution and paleoanthropology, focusing on recent advances in all those research areas investigating the brain form in extinct species. The book includes chapters on craniology, digital techniques, endocast reconstruction, craniovascular traits, surface analyses, landmarking, and on the relationships between the brain and the braincase. Furthermore, the volume includes chapters concerning the principal brain districts, and reviews the current knowledge regarding their evolution in humans and in nonhuman primates. The aim is to supply a comprehensive and updated reference on the challenges, advances, and limitations associated with the study of the brain form and functions in fossils, introducing the current state of the art and future directions of human paleoneurology.

Burgos, Spain
Yokohama, Japan
Nagoya, Japan

Emiliano Bruner
Naomichi Ogihara
Hiroki C. Tanabe

Contents

1	On the Making of Endocasts: The New and the Old in Paleoneurology . . .	1
	Ralph L. Holloway	
2	Digital Reconstruction of Neanderthal and Early <i>Homo sapiens</i> Endocasts	9
	Naomichi Ogihara, Hideki Amano, Takeo Kikuchi, Yusuke Morita, Hiromasa Suzuki, and Osamu Kondo	
3	Inferring Cortical Subdivisions Based on Skull Morphology	33
	Yasushi Kobayashi, Toshiyasu Matsui, and Naomichi Ogihara	
4	Fossil Primate Endocasts: Perspectives from Advanced Imaging Techniques	47
	Amélie Beaudet and Emmanuel Gilissen	
5	The Evolution of Avian Intelligence and Sensory Capabilities: The Fossil Evidence	59
	Stig A. Walsh and Fabien Knoll	
6	The Endocranial Vascular System: Tracing Vessels	71
	Gizéh Rangel de Lázaro, Stanislava Eisová, Hana Pířová, and Emiliano Bruner	
7	The Brain, the Brainspace, and the Morphospace	93
	Emiliano Bruner	
8	Landmarking Brains	115
	Aida Gómez-Robles, Laura D. Reyes, and Chet C. Sherwood	
9	Landmarking Endocasts	127
	Ana Sofia Pereira-Pedro and Emiliano Bruner	
10	Comparing Endocranial Surfaces: Mesh Superimposition and Coherent Point Drift Registration	143
	Ján Dupej, Gizéh Rangel de Lázaro, Ana Sofia Pereira-Pedro, Hana Pířová, Josef Pelikán, and Emiliano Bruner	
11	Reconstruction and Statistical Evaluation of Fossil Brains Using Computational Neuroanatomy	153
	Takanori Kochiyama, Hiroki C. Tanabe, and Naomichi Ogihara	
12	Endocasts and the Evo-Devo Approach to Study Human Brain Evolution . . .	173
	Simon Neubauer and Philipp Gunz	
13	Networking Brains: Modeling Spatial Relationships of the Cerebral Cortex . . .	191
	Emiliano Bruner, Borja Esteve-Altava, and Diego Rasskin-Gutman	

14	The Evolution of the Frontal Lobe in Humans	205
	Ashley N. Parks and Jeroen B. Smaers	
15	The Evolution of the Parietal Lobes in the Genus <i>Homo</i>	219
	Emiliano Bruner, Hideki Amano, Ana Sofia Pereira-Pedro, and Naomichi Ogihara	
16	A Comparative Perspective on the Human Temporal Lobe	239
	Katherine L. Bryant and Todd M. Preuss	
17	Evolution of the Occipital Lobe	259
	Orlin S. Todorov and Alexandra A. de Sousa	
18	Cerebellum: Anatomy, Physiology, Function, and Evolution	275
	Hiroki C. Tanabe, Daisuke Kubo, Kunihiro Hasegawa, Takanori Kochiyama, and Osamu Kondo	