The Handbook of Phonetic Sciences

Second Edition

Edited by

William J. Hardcastle, John Laver and Fiona E. Gibbon

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WILEY-BLACKWELL
A John Wiley & Sons, Ltd., Publication

This paperback edition first published 2013

Edition History: Blackwell Publishing Ltd (1e, 1997; 2e hardback, 2010)

Blackwell Publishing was acquired by John Wiley & Sons in February 2007. Blackwell's publishing program has been merged with Wiley's global Scientific, Technical, and Medical business to form Wiley-Blackwell.

Registered Office

John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial Offices

350 Main Street, Malden, MA 02148-5020, USA

9600 Garsington Road, Oxford, OX4 2DQ, UK

The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

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Library of Congress Cataloging-in-Publication Data

The handbook of phonetic sciences/edited by William J. Hardcastle, John Laver, Fiona E. Gibbon. – 2nd ed.

p. cm. – (Blackwell handbooks in linguistics)

Includes bibliographical references and index.

ISBN 978-1-4051-4590-9 (hardcover : alk. paper) ISBN 978-1-118-35820-7 (paperback: alk. paper)

1. Phonetics–Handbooks, manuals, etc. I. Hardcastle, William J., 1943– II. Laver, John. III. Gibbon, Fiona E.

P221.H28 2009

414′.8–dc22

2009033872

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

Cover image: Ceremonial, 1999 by Ignacio Auzike/Getty

Cover design by Workhaus

For Peter Ladefoged and Gunnar Fant, who led the field

Contributors

Hermann Ackermann
University of Tübingen

Janet Mackenzie Beck
Queen Margaret University, Edinburgh

Mary E. Beckman
Ohio State University

Rolf Carlson
KTH Royal Institute of Technology, Stockholm

Anne Cutler
Max Planck Institute for Psycholinguistics, Nijmegen
MARCS Auditory Laboratories, University of Western Sydney

Barbara L. Davis
University of Texas

Daniel P. W. Ellis
Columbia University

John H. Esling
University of Victoria

Edda Farnetani
Centro di Studio per le Richerche di Fonetica del CNR, Padova

Janet Fletcher
University of Melbourne

Paul Foulkes
University of York

Christer Gobl
Trinity College Dublin

Björn Granström
KTH Royal Institute of Technology, Stockholm

Helen M. Hanson
Union College, New York

Jonathan Harrington
University of Munich

Hajime Hirose
Kitasato University

Simon King
University of Edinburgh

Anders Löfqvist
Haskins Laboratories, New Haven

James M. McQueen
Max Planck Institute for Psycholinguistics, Nijmegen
Radboud University Nijmegen

Brian C. J. Moore
University of Cambridge

Ailbhe Ní Chasaide
Trinity College Dublin

John J. Ohala
University of California at Berkeley

Daniel Recasens
Universitat Autònoma de Barcelona

Steve Renals
University of Edinburgh

James M. Scobbie
Queen Margaret University, Edinburgh

Christine H. Shadle
Haskins Laboratories, New Haven

Anne Smith
Purdue University

Kenneth N. Stevens
Massachusetts Institute of Technology

Maureen Stone
University of Maryland

Jennifer J. Venditti
San Jose State University

Dominic Watt
University of York

Wolfram Ziegler
City Hospital, Bogenhausen, Munich

Preface to the Second Edition

It is now over 10 years since the publication of the first edition of *The Handbook of Phonetic Sciences*. Since then the phonetic sciences have developed substantially and there are now many more disciplines taking a professional interest in speech-related areas. This multidisciplinary orientation continues to be reflected in the second edition.

In this second edition, 32 leading researchers have contributed 22 chapters in 5 major sectors of the contemporary subject. As with the first edition, an elementary knowledge of the field is assumed and each chapter presents an overview of a key area of the expertise which makes up the wide range of the phonetic sciences today.

There are a number of chapters retained from the first edition which have been substantially updated by the authors. These include the chapters by Stone, Shadle, Hirose, Mackenzie Beck, Farnetani and Recasens, Löfqvist, Gobl and Ní Chasaide, Stevens and Hanson, Moore, McQueen and Cutler, Ohala, Carlson and Granström. Other topic areas from the first edition have been given completely new treatment by newly commissioned authors (chapters by Harrington, Ackermann and Ziegler, Smith, Davis, Ellis, Renals and King). There are also two new chapters covering sociophonetics (Scobbie, Foulkes, and Watt) and phonetic notation (Esling). To reflect the increasing significance of the area of prosody in the phonetic sciences we have also included two commissioned chapters covering the areas of timing and rhythm (Fletcher), and tone and intonation (Beckman and Venditti).

For readers with complementary interests in phonology and clinical phonetics and linguistics the companion

volumes to this handbook, *The Handbook of Phonological Theory* (Goldsmith, 2010, 2nd edn.) and *The Handbook of Clinical Linguistics* (Ball, Perkins, Müller, & Howard, 2008) are recommended.

We would like to thank a number of colleagues for their assistance with editorial work, including Annabel Allen, Pauline Campbell, Erica Clements, Sue Peppe, and Sonja Schaeffler. Special thanks are also due to Anna Oxbury for her meticulous and thoughtful copy-editing.

The editors

Introduction

WILLIAM J. HARCASTLE, JOHN LAVER, AND FIONA E. GIBBON

As with the first edition, the book is divided into five major sections. The first part begins with an account of the main measurement techniques, methodologies, and instruments found in experimental phonetic laboratories. The next part explores aspects of the anatomical and physiological framework for normal and disordered speech production. The third and largest part of the book focuses on the acquisition of speech and theories and models of speech production and perception. The fourth part deals with the linguistic motivation of much research in the phonetic sciences in covering a number of key areas of linguistic phonetics. The final part returns to experimental approaches to the phonetic sciences but this time focusing on speech signal processing and engineering in an overview of the main developments in speech technology. There are extensive pointers to further reading in each chapter.

Part I has four chapters on the topic of Experimental Phonetics. The section begins with a critical evaluation by Maureen Stone on current laboratory techniques that measure the oral vocal tract during speech. The focus is on instruments that measure the articulators directly and indirectly. Indirect measurements come from instruments that are remote from the structures of interest such as imaging techniques (e.g., X-ray, MRI, and ultrasound). Direct measurements come from instruments that contact the structures of interest, such as, point-tracking devices and electropalatography. References are made to current

research using each instrument in order to indicate its applications and strengths.

Experimental approaches to speech production are explored further by Christine Shadle in the next chapter on the aerodynamics of speech. This chapter begins by defining aerodynamics and reviews the basic concepts of fluid statics and dynamics (including turbulence), and aerodynamically distinct vocal tract behaviors are discussed. This is followed by a section covering measurement methods, divided into basic methods such as pressure and flow velocity measurement, and speech-adapted methods such as the Rothenberg mask and methods for measuring or estimating lung volume and subglottal pressure, and the use of hot-wires to measure flow velocities in the vocal tract. A final section describes models of speech production that incorporate aerodynamics.

Acoustic phonetics is the subject of the third chapter by Jonathan Harrington. This new chapter provides an overview of the acoustic characteristics of consonants and vowels from the perspective of a broad range of research questions in experimental phonetics and laboratory phonology. Various procedures for the phonetic classification of the acoustic speech signal are reviewed including the identification of vowel height and backness from various transformed acoustic spaces, the derivation of place of articulation in oral stops from burst and locus cues, and techniques for distinguishing between fricatives based on parameterizing spectral shape. These techniques are informed by a knowledge of speech production and are related to speech perception, and they also establish links to pattern classification in signal processing.

Investigating the physiology of laryngeal structures is the subject of the final chapter in this section. In this chapter, Hajime Hirose describes specialized, newly developed

techniques for observing laryngeal behavior during speech production, including flexible fiberscopy, high-speed digital imaging, laryngeal electromyography, photoglottography, electroglottography, and magnetic resonance imaging. Basic behaviors of the laryngeal structures are described with reference to the results of observation obtained by the above techniques and the nature of laryngeal adjustments that take place under different phonetic conditions.

Part II contains three chapters on biological perspectives and opens with an exploration by Janet Mackenzie Beck on organic variation and the ways it affects the vocal apparatus. She points to two main sources of variation in speech performance: phonetic variation resulting from differences in the way individuals use their vocal apparatus, and organic variation depending on individual differences in inherent characteristics of the vocal organs. The chapter focuses on organic variation bringing together information from a variety of sources, anatomical, physiological, anthropological. Three main types of differences in the structure of the vocal apparatus are discussed: the life-cycle changes within an individual; genetic or environmental factors which differentiate between individuals; and differences which result from trauma or disease.

Hermann Ackermann and Wolfram Ziegler in their chapter on brain mechanisms underlying speech motor control begin with an overview of the topic. Their discussions draw upon data derived from three approaches, namely, electrical surface stimulation of the cortex, lesion studies in patients with neurogenic communication disorders, and functional imaging techniques. These discussions are preceded by a review of experimental studies in subhuman primates addressing the corticobulbar representation of orofacial muscles as well as the cerebral correlates of vocal behavior.

The final chapter in Part II is by Anne Smith and concerns the development of neural control for speech. She gives an

integrative overview of studies of the development of the neuromotor processes involved in controlling articulatory movements for speech. The area of speech motor development has not been critically reviewed recently and this chapter provides a detailed summary of major advances in understanding the time course of maturation of speech motor control processes, which, contrary to earlier claims, are not adult-like until late adolescence. Discussions of theoretical issues in speech motor development, such as the units involved in the language–motor interface and the issues of neural plasticity and sensitive periods in speech motor development, portray important, ongoing debates in this area.

Part III contains seven chapters on the topic of modeling speech production and perception. The first is a chapter on speech acquisition by Barbara Davis. She addresses the question of how young children integrate biology and cognition to achieve the necessary capacities for the phonological component of linguistic communication. The chapter outlines how contemporary theoretical perspectives and research paradigms consider the nature of speech acquisition. These include formalist phonological perspectives representing a consistent strand of proposals on acquisition of sound patterns in languages. She contrasts this approach with functionalist phonetic science perspectives that have focused on biological characteristics of the developing child and the ways in which these capacities contribute to emergence of complex speech output patterns.

The chapter by Edda Farnetani and Daniel Recasens presents an overview of the current knowledge concerning coarticulation and connected speech processes. The authors address the nature of coarticulatory and assimilatory processes in connected speech, and explore the foundations and predictions of the most relevant theoretical models of

labial, velar, and lingual coarticulation (feature spreading, time-locked, locus equation, adaptive variability, window model, and coarticulatory resistance). They describe the significant theoretical and experimental progress in understanding contextual variability, which is reflected in continuously evolving and improving models, and in increasingly rigorous and sophisticated research methodologies.

Theories and models of speech production are developed further by Anders Löfqvist, particularly from the point of view of spatial and temporal control of speech movements. In his chapter, theoretical and empirical approaches to speech production converge in their focus on understanding how the different parts of the vocal tract are flexibly marshaled and coordinated to produce the acoustic signal that the speaker uses to convey a message. He outlines a variety of experimental paradigms and how these are applied to the problem of coordination and control in motor systems with excess degrees of freedom.

An area of key theoretical and technical importance is the nature of the voice source and how it varies in speech. The chapter by Christer Gobl and Ailbhe Ní Chasaide is concerned with acoustic aspects of phonation and its exploitation in speech communication. The early sections focus on the source signal itself, on analysis techniques, and provide acoustic descriptions of different voice qualities. The later sections describe how variations in the voice source are associated with segmental or suprasegmental aspects of the linguistic code, and discuss the role of voice quality in the paralinguistic signaling of emotion, mood, and attitude. The sociolinguistic function in differentiating among linguistic, regional, and social groups is briefly outlined, as well as its important role in speaker identification.

The next chapter by Kenneth Stevens and Helen Hanson focuses on articulatory–acoustic relations as the basis of