

The Cambridge Handbook of Phonetics

Phonetics – the study and classification of speech sounds – is a major sub-discipline of linguistics. Bringing together a team of internationally renowned phoneticians, this handbook provides comprehensive coverage of the most recent, cutting-edge work in the field, and focuses on the most widely debated contemporary issues. Chapters are divided into five thematic areas: segmental production, prosodic production, measuring speech, audition and perception, and applications of phonetics. Each chapter presents a historical overview of the area, along with critical issues, current research and advice on the best practice for teaching phonetics to a range of students. It brings together global perspectives, and includes examples from a wide range of languages, allowing readers to extend their knowledge beyond English. By providing both state-of-the-art research information, and an appreciation of how it can be shared with students, this handbook is essential both for academic phoneticians, and anyone with an interest in this exciting, rapidly developing field.

RACHAEL-ANNE KNIGHT is Professor of Phonetics at City, University of London, with interests in prosody, transcription and pedagogy. She is the author of the successful *Phonetics: A Coursebook* (2012), and is a National Teaching Fellow and Principal Fellow of the Higher Education Academy.

JANE SETTER is Professor of Phonetics at the University of Reading, with interests in global Englishes, prosody and pedagogy. Author of *Your Voice Speaks Volumes* (2019) and co-editor of the *Cambridge English Pronouncing Dictionary* (2011), Jane is a National Teaching Fellow and Senior Fellow of the Higher Education Academy.

CAMBRIDGE HANDBOOKS IN LANGUAGE AND LINGUISTICS

Genuinely broad in scope, each handbook in this series provides a complete state-of-the-field overview of a major sub-discipline within language study and research. Grouped into broad thematic areas, the chapters in each volume encompass the most important issues and topics within each subject, offering a coherent picture of the latest theories and findings. Together, the volumes will build into an integrated overview of the discipline in its entirety.

Published titles

- The Cambridge Handbook of Phonology*, edited by Paul de Lacy
The Cambridge Handbook of Linguistic Code-switching, edited by Barbara E. Bullock and Almeida Jacqueline Toribio
The Cambridge Handbook of Child Language, Second Edition, edited by Edith L. Bavin and Letitia Naigles
The Cambridge Handbook of Endangered Languages, edited by Peter K. Austin and Julia Sallabank
The Cambridge Handbook of Sociolinguistics, edited by Rajend Mesthrie
The Cambridge Handbook of Pragmatics, edited by Keith Allan and Kasia M. Jaszczolt
The Cambridge Handbook of Language Policy, edited by Bernard Spolsky
The Cambridge Handbook of Second Language Acquisition, edited by Julia Herschensohn and Martha Young-Scholten
The Cambridge Handbook of Bilingualism, edited by Cedric Boeckx and Kleantes K. Grohmann
The Cambridge Handbook of Generative Syntax, edited by Marcel den Dikken
The Cambridge Handbook of Communication Disorders, edited by Louise Cummings
The Cambridge Handbook of Stylistics, edited by Peter Stockwell and Sara Whiteley
The Cambridge Handbook of Linguistic Anthropology, edited by N. J. Enfield, Paul Kockelman and Jack Sidnell
The Cambridge Handbook of English Corpus Linguistics, edited by Douglas Biber and Randi Reppen
The Cambridge Handbook of Bilingual Processing, edited by John W. Schwieter
The Cambridge Handbook of Learner Corpus Research, edited by Sylviane Granger, Gaëtanelle Gilquin and Fanny Meunier
The Cambridge Handbook of Linguistic Multicompetence, edited by Li Wei and Vivian Cook
The Cambridge Handbook of English Historical Linguistics, edited by Merja Kytö and Päivi Pahta
The Cambridge Handbook of Formal Semantics, edited by Maria Aloni and Paul Dekker
The Cambridge Handbook of Morphology, edited by Andrew Hippisley and Greg Stump
The Cambridge Handbook of Historical Syntax, edited by Adam Ledgeway and Ian Roberts
The Cambridge Handbook of Linguistic Typology, edited by Alexandra Y. Aikhenvald and R. M. W. Dixon
The Cambridge Handbook of Areal Linguistics, edited by Raymond Hickey
The Cambridge Handbook of Cognitive Linguistics, edited by Barbara Dancygier
The Cambridge Handbook of Japanese Linguistics, edited by Yoko Hasegawa

Cambridge University Press
978-1-108-49573-8 — The Cambridge Handbook of Phonetics
Edited by Rachael-Anne Knight, Jane Setter
Frontmatter
[More Information](#)

- The Cambridge Handbook of Spanish Linguistics*, edited by Kimberly L. Geeslin
The Cambridge Handbook of Bilingualism, edited by Annick De Houwer and Lourdes Ortega
The Cambridge Handbook of Systemic Functional Linguistics, edited by Geoff Thompson, Wendy L. Bowcher, Lise Fontaine and David Schönthal
The Cambridge Handbook of African Linguistics, edited by H. Ekkehard Wolff
The Cambridge Handbook of Language Learning, edited by John W. Schwieter and Alessandro Benati
The Cambridge Handbook of World Englishes, edited by Daniel Schreier, Marianne Hundt and Edgar W. Schneider
The Cambridge Handbook of Intercultural Communication, edited by Guido Rings and Sebastian Rasinger
The Cambridge Handbook of Germanic Linguistics, edited by Michael T. Putnam and B. Richard Page
The Cambridge Handbook of Discourse Studies, edited by Anna De Fina and Alexandra Georgakopoulou
The Cambridge Handbook of Language Standardization, edited by Wendy Ayres-Bennett and John Bellamy
The Cambridge Handbook of Korean Linguistics, edited by Sungdai Cho and John Whitman
The Cambridge Handbook of Phonetics, edited by Rachael-Anne Knight and Jane Setter

The Cambridge Handbook of Phonetics

Edited by

Rachael-Anne Knight

City, University of London

Jane Setter

University of Reading



CAMBRIDGE
UNIVERSITY PRESS

Cambridge University Press
978-1-108-49573-8 — The Cambridge Handbook of Phonetics
Edited by Rachael-Anne Knight, Jane Setter
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

103 Penang Road, #05–06/07, Visioncrest Commercial, Singapore 238467

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/9781108495738

DOI: 10.1017/9781108644198

© Cambridge University Press 2022

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 2022

Printed in the United Kingdom by TJ Books Limited, Padstow Cornwall

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

ISBN 978-1-108-49573-8 Hardback

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>List of Figures</i>	page ix
<i>List of Tables</i>	xiii
<i>List of Contributors</i>	xv
Introduction <i>Rachael-Anne Knight and Jane Setter</i>	1
Section I Segmental Production	9
1 Physiological Foundations <i>Alan Wrench and Janet Beck</i>	11
2 Vowels <i>Jarostaw Weckwerth</i>	40
3 Consonants <i>Michael Proctor</i>	65
4 Coarticulation <i>Khalil Iskarous and Christine Mooshammer</i>	106
5 Processes in Connected Speech <i>Natasha Warner</i>	133
Section II Prosodic Production	157
6 Stress and Rhythm <i>Marina N. Cantarutti and Beatrice Szczepek Reed</i>	159
7 Lexical Tone <i>Albert Lee and Peggy Mok</i>	185
8 Intonation <i>Paul Warren and Sasha Calhoun</i>	209
9 Voice Quality <i>John H. Esling and Scott R. Moisik</i>	237
Section III Measuring Speech	259
10 Measuring Vowels <i>Byunggon Yang</i>	261
11 Measuring Consonants <i>Mauricio Figueroa and Young Shin Kim</i>	285
12 Measuring Speech Rhythm <i>Amalia Arvaniti</i>	312
13 Fundamental Frequency and Pitch <i>Daniel Hirst and Céline De Looze</i>	336
14 Observing and Measuring Speech Articulation <i>Susan Lin</i>	362
15 Beyond Functional Speech Synthesis <i>Rupal Patel, Geoffrey Meltzner and Markus Toman</i>	387

Section IV	Audition and Perception	405
16	Neurological Foundations of Phonetic Sciences <i>Francis C. K. Wong, Mark Antoniou and Patrick C. M. Wong</i>	407
17	Psycholinguistic Aspects <i>Meghan Sumner and Seung Kyung Kim</i>	430
18	Phonetics and Eye-Tracking <i>Eva Reinisch and Holger Mitterer</i>	457
19	Automatic Speech Recognition by Machines <i>Sabato Marco Siniscalchi and Chin-Hui Lee</i>	480
Section V	Applications of Phonetics	501
20	Pedagogical Approaches <i>Rachael-Anne Knight, Jane Setter and Nicole Whitworth</i>	503
21	Pronunciation Teaching <i>Jane Setter and Takehiko Makino</i>	527
22	Sociophonetics <i>Katie Drager and Thomas Kettig</i>	551
23	Developmental Phonetics of Speech Production <i>Yvan Rose, Tara McAllister and Sharon Inkelas</i>	578
24	Clinical Phonetics <i>Matthew Moreland</i>	603
25	Forensic Phonetics <i>Toby Hudson, Kirsty McDougall and Vincent Hughes</i>	631
26	The Phonetics of Talk in Interaction <i>Richard Ogden</i>	657
27	The Phonetics/Phonology Interface <i>Robert Kennedy</i>	682
	<i>Index</i>	707

Figures

1.1	Organisation of motor system for simple speech tasks	<i>page</i> 13
1.2	Brainstem nuclei and section through lower pons showing facial nucleus with subnuclear regions	15
1.3	Musculature of respiration	17
1.4	Extrinsic muscle of larynx/hyoid	18
1.5	Abduction and adduction of the vocal folds	19
1.6	Diagram of midsagittal section of the vocal tract and ultrasound image indicating hyoid bone, geniohyoid muscle, short tendon of the genioglossus and mandible	22
1.7	(a) Muscles of the tongue (b) Anterior and posterior stirrups (aka slings). These facilitate tongue retraction and bunching	28
1.8	Muscles of the jaw	29
1.9	(a) Orbicularis oris: contraction directions of subcompartments (b) Muscles of lips	30
1.10	Vocal tract divided into regions with primary articulators indicated for each region	32
2.1	Approximate locations of some vowels on the edge of the vowel space	42
2.2	The official International Phonetic Association vowel chart	45
2.3	Plots of the first formant against the second formant for vowels in American English and Mexico City Spanish vowels	47
2.4	Catford's polar vowel diagram (1977, p. 185)	48
2.5	The vowels of Standard Southern British English	51
2.6	Average Standard Southern British English formant values	53
3.1	Contrastive places of articulation	70
3.2	Articulation of an affricated bilabial ejective [pʰʼ]	73
3.3	Place contrasts in Nama (Khoekhoegowab) clicks	74
3.4	Constrictions characterising English sibilant fricatives	76
3.5	Articulation of a nasal stop	79

3.6	Comparison of lateral and central articulation	80
4.1	Temporal model of co-production	110
4.2	Simulated and actual F2 for American English word <i>bid</i>	120
5.1	Waveform and spectrogram of spontaneous conversational speech by a female native speaker of American English	134
5.2	Waveform and spectrogram of spontaneous conversational speech by a female native speaker of American English	139
5.3	Waveform and spectrogram of spontaneous conversational speech by a female native speaker of American English	140
5.4	Waveform and spectrogram of spontaneous conversational speech by a male native speaker of Japanese	141
6.1	Waveform and f_0 trace of the English word <i>afternoon</i>	161
6.2	Metrical tree representation of the English word <i>information</i>	163
6.3	Metrical grid representation of the Rhythm Rule application in <i>afternoon tea</i>	164
6.4	Interlinear representation of <i>afternoon</i> and <i>afternoon tea</i>	165
6.5	Rhythmic integration	173
7.1	Schematic diagrams of inertia-induced carryover assimilation, downstep and pre-low raising	190
8.1	Examples of ToBI annotation for English	211
8.2	Diagrammatic representation of intrinsic, and local and global extrinsic effects on pitch span	212
8.3	Examples of subject, verb, object and broad focus in Mandarin Chinese	216
8.4	Example pitch tracks for (1), showing broad focus and narrow focus on /irjoire/ 'on Sunday' in Korean	218
8.5	Example of cross-linguistic differences in the phonetic realisation of falling and rising accents	220
9.1	A frame from a cineradiographic video of the first author during the stricture phase of voiceless aryepiglottic trilling	243
9.2	Midsagittal lingual ultrasound traces showing hyoid position and tongue contour change in pharyngealised and aryepiglottalised (growled) variants of [ɹ] and [j] compared to 'double-bunched' productions of [ɹ] and plain [j]	245
9.3	Static midsagittal MRI comparing sustained [i] in modal voice with sustained [i] in raised-larynx voice produced by the second author	246
9.4	Voice Qualities page of the <i>iPA Phonetics</i> app	249
9.5	The IPA vowel chart adapted to reflect the articulatory terminology of the <i>iPA Phonetics</i> Voice Qualities map	250

10.1	A waveform and the formant trajectories on a wideband spectrogram of the English word <i>hood</i> as produced by a Canadian speaker	264
10.2	The durational difference of vowels before voiced and voiceless codas ([d] vs. [t]) as produced by an American speaker	266
10.3	A waveform and pitch and intensity contours of the word <i>happy</i> as produced by a Canadian speaker	267
10.4	A waveform and a narrowband spectrogram of the first vowel of the word <i>happy</i>	268
10.5	Vowel chart (F2×F1) showing English and Korean vowels of male speakers scaled by a uniform normalisation	274
11.1	Representation of the spectral characteristics of four Chilean Spanish fricatives [f], [s], [ʃ] and [x] (allophones of /f/, /s/, /tʃ/ and /x/, respectively)	290
11.2	Calculation of VOT values for a voiced [d] and a voiceless aspirated plosive [t ^h], from the English word <i>daughter</i> ['dɔ:t ^h ə], elicited in citation form	293
11.3	FFT spectrum calculated in a 25 ms window located at the onset of a vowel [a], following the non-aspirated voiceless plosive [p] (both from Spanish)	295
11.4	Denasalised nasal [m̃] and nasal [m] from Korean, taken from the word [e.m̃e.'mil] subjective particle + <i>buckwheat</i>	299
11.5	Graphical visualisation of a 16-channel filterbank analysis for [b], [m̃] and [m], data averaged from eight speakers	300
11.6	Waveform and spectrogram representations of seven approximants in VCV structures	302
12.1	The hierarchical relationship between elements in the word <i>photographic</i>	325
13.1	Sample transcriptions from Jones (1909)	337
13.2	The waveform of a portion of a vowel /a:/ with one period highlighted	338
13.3	Speech signal and f ₀ for two French phrases pronounced with a declarative intonation pattern	339
13.4	The output of the Prosogram algorithm applied to a French utterance	340
13.5	Analysis-by-synthesis of a Japanese sentence as a superposition of phrase components and accent components	340
13.6	Pitch scales	347
13.7	Fundamental frequency of the phrase 'once the eggs hatch'	350
13.8	Graphical representation of the average bottom tones and the average top tones using the Momel-INTSINT algorithms compared to the speaker's median pitch	354
13.9	Pitch patterns for two speakers, one female and one male, reading the sentence 'What can I have for dinner tonight?'	355

14.1	Three methods for direct imaging	371
14.2	EMA tracking of the tongue tip and back, and corresponding waveform	374
14.3	Two indirect imaging methods	378
15.1	The relationship between a speech signal and statistical models estimated from it	392
15.2	Overview of VocaliD's BeSpoke voice creation process	397
16.1	Activation peaks and activation clusters that have been reported to be elicited by phonological processing tasks	409
16.2	Spectrograms of sample materials used in Okada et al. (2010)	411
16.3	Conventional univariate analysis and multivariate pattern analysis of brain imaging data	412
16.4	Diffusion tensor imaging	414
16.5	Some of the brain regions mentioned in this chapter	421
18.1	Example of an experimental display used in Mitterer and McQueen (2009) and the results obtained	463
19.1	Automatic speech understanding	482
19.2	A Hidden Markov Model for the word <i>read</i>	487
19.3	Top-down ASR paradigm	488
19.4	Bottom-up ASR paradigm	489
19.5	Prosodic analysis of the WSJ sentence 'If the Fed pushes the dollar higher, it may curb the demand for US exports.'	490
19.6	The ASAT speech recognition framework	491
19.7	Detection curves for manner of articulation for the sentence 'Rates fell on short-term treasury bills.'	493
21.1	Interlinear diagram to accompany Example (1)	544
23.1	Differences in configuration between infant and adult vocal tracts	581
24.1	Aetiological classification of voice disorders	616
25.1	Visualisation of a notional 'speaker space' for three speech features	639
25.2	Verbal likelihood framework for conclusions	646

Tables

1.1 Organisation of motor nuclei involved in speech production	page 14
1.2 Respiratory muscle function	16
1.3 Key muscles of the larynx	20
1.4 Muscles of the hyoid and floor of the mouth	21
1.5 Muscles of the pharynx	23
1.6 Muscles of the velum	24
1.7 Muscles of the tongue	26
1.8 Muscles of the jaw	29
1.9 Muscles of the lips	30
2.1 Selected Southern British English vowel phonemes in three phonemic transcription systems	52
3.1 Phonetically contrastive properties of consonants	66
3.2 Tract variables and associated articulators in Articulatory Phonology	71
3.3 Consonant airstream mechanisms	72
3.4 Laryngeal settings for consonants	78
3.5 Articulatory characterisation of complex consonants	85
12.1 Comparison of nPVI scores between languages said to belong to different classes and the same class	323
12.2 Average duration of inter-stress intervals by language	326
14.1 Number of research papers appearing in <i>Journal of Phonetics</i> , <i>the Journal of the Acoustical Society of America</i> and <i>Laboratory Phonology</i> from June 2018 to May 2019, by their methodologies	363
14.2 Summary of methods described, including relative invasiveness, level of training required to operate, portability and temporal resolution	367
16.1 Factorial design in Scott et al. (2000) and Okada et al. (2010)	410
22.1 Correspondences between IPA in Southern Standard British English and General American English, Wells's lexical	

	set labels, adaptations of lexical sets used in PADS volumes, and Labovian notation	553
22.2	Example topics and readings for a course on sociophonetics	565
23.1	Segmental patterns	584

Contributors

Rachael-Anne Knight is Professor of Phonetics, and former Associate Dean Education, at City, University of London, UK. Her research interests include prosodic aspects of English, intelligibility in relation to regional accents and speech sound disorders, and the processes underlying phonetic transcription. Beyond phonetics she also researches educational issues, such as how storytelling can support students in higher education. She is a National Teaching Fellow and a Principal Fellow of the Higher Education Academy (AdvanceHE).

Jane Setter is Professor of Phonetics at the University of Reading, UK. Her research interests include speech prosody in children from atypical populations, teaching and learning English pronunciation, and features of the phonology of global varieties of English, such as Hong Kong and Malay speaker English. A passionate advocate of working with students as partners in the higher education curriculum, she is a National Teaching Fellow and a Senior Fellow of the Higher Education Academy (AdvanceHE).

Mark Antoniou is an Associate Professor and the Deputy Director of The MARCS Institute for Brain, Behaviour and Development at Western Sydney University, Australia. His research encompasses cognitive, neuroscientific and developmental aspects of language learning and use, including bilingualism.

Amalia Arvaniti is Professor of English Language and Linguistics at Radboud University in the Netherlands. From 2015 to 2019, she was the editor of the *Journal of the International Phonetic Association*. She is the Vice-President of the International Phonetic Association and Chair of the ICPHS Permanent Council (2019–2024). Her research, which focuses on the cross-linguistic study of prosody, has been widely published and cited, and has led to notable paradigm shifts in our understanding of intonation and rhythm. She is the recipient of a European Research

Council Advanced Grant to study intonation (2019–2024), and of a Leverhulme Major Research Fellowship (2019–2021) to study the Greek sound system in light of re-emerging diglossia.

Janet Beck is a Professor and the Head of Division of Speech and Hearing Sciences at Queen Margaret University, Edinburgh, UK. Key research interests include the development and application of techniques for phonetic analysis of voice quality in clinical and research contexts and the interrelationships between individual variations in anatomy and speech quality.

Sasha Calhoun is a Senior Lecturer in the School of Linguistics and Applied Language Studies at Victoria University of Wellington, New Zealand. Her research focuses on the functions of prosody and intonation, especially information structure, across languages, including Samoan, te reo Māori, Chinese, Spanish and German, as well as English. Her work has appeared in *Language*, *Laboratory Phonology*, *Glossa*, *Frontiers in Psychology*, *Language and Speech*, *Journal of Phonetics*, *Language and Cognitive Processes* and *Speech Communication*. She was one of the Scientific Chairs for the 19th International Congress of Phonetic Sciences, held in Melbourne in 2019, and is on the Executive Council of the Association of Laboratory Phonology.

Marina N. Cantarutti is a Postdoctoral Research Associate at the Open University, UK, with a PhD in Language and Communication from the University of York, UK. She has lectured in English phonetics at several teacher training colleges and translation programmes in Buenos Aires, Argentina, where she graduated as an EFL teacher and MA in English Language. Her current research centres around the practice of ‘co-animation’ (i.e. joint reported speech) in everyday conversation in English, and her studies focus on the interplay of phonetics, grammar and gesture, and how they are deployed and organised in interaction for social affiliation. Other research interests include the teaching of prosody to L2 learners of English from discourse and genre perspectives.

Céline De Looze is a Research Fellow in Medical Gerontology at The Longitudinal Study on Ageing Research (TILDA), School of Medicine, in Trinity College Dublin, Ireland. Her research encompasses a wide range of disciplines, including speech prosody, cognitive functioning and healthy brain ageing. Her research focuses on the development of new quantitative methods for the assessment of speech prosody, cognitive communication, cognitive function and brain health. Her scientific approach combines knowledge from clinical linguistics, phonetics and neuropsychology with methods and technologies from social signal processing, imaging and human factors engineering.

Katie Drager is an Associate Professor in the Department of Linguistics at the University of Hawai‘i at Mānoa. Her work examines the link between sounds and social meanings, especially how expectations about a talker can influence how listeners interpret the sounds they produce.

John H. Esling is Professor Emeritus of Linguistics at the University of Victoria, British Columbia, Canada, and former Secretary of the IPA, Editor of the *Journal of the International Phonetic Association*, and President of the IPA. A Fellow of the Royal Society of Canada, his research covers auditory and articulatory phonetics, the categorisation of voice quality, infant acquisition of the speech modality, and the phonetic production and modelling of laryngeal and pharyngeal sounds. His collaborations include the *Handbook of the IPA* (Cambridge University Press, 1999), the *Cambridge English Pronouncing Dictionary* (Cambridge University Press, 2011), the *iPA Phonetics* app, and *Voice Quality: The Laryngeal Articulator Model* (Cambridge University Press, 2019).

Mauricio Figueroa is an Assistant Professor in the Spanish Department at Universidad de Concepción, Chile. He recently completed a PhD in Speech, Hearing and Phonetic Sciences at University College London, which focused on how listeners cope with the lenition of segmental units during perception tasks which may or not require lexical access. His current research uses quantitative approaches to better understand the sociophonetic dynamics of several varieties of Chilean Spanish, and to improve existing descriptions of the phonetic and phonemic systems of some of Chile's native languages.

Daniel Hirst has been working in the field of speech prosody and phonology for nearly fifty years. Currently Emeritus Research Director for the CNRS in Aix-en-Provence, France, he has published numerous articles/chapters in several major journals/international volumes, as well as Hirst and Di Cristo (eds.), *Intonation Systems: A Survey of Twenty Languages* (Cambridge University Press, 1998). He has developed software for the automatic analysis of speech prosody (Momel, INTSINT, ProZed), implemented as plugins for the Praat software. In 2002 he organised the first International Conference on Speech Prosody, in Aix-en-Provence, France. In 2013 he was elected fellow of ISCA, in 2014 member of the Permanent Council for the Organisation of ICPhS and in 2018 ISCA distinguished lecturer (2018–2019).

Toby Hudson is a DPhil candidate in Linguistics, Philology and Phonetics at the University of Oxford, UK, where he also lectures in Phonetics and Phonology. His research concerns the acoustics of sound change. Previously he was engaged in forensic research projects at the University of Cambridge and criminal casework in the UK. He takes a keen interest in speech technology and has been employed as senior research engineer at Samsung Research UK and consultant to other leading international companies.

Vincent Hughes is a Lecturer in Forensic Speech Science in the Department of Language and Linguistic Science at the University of York, UK. He is also a Fellow of the Higher Education Academy. His research interests lie in forensic speech science (in particular, forensic

speaker comparison), forensic statistics, automatic speaker recognition, sociolinguistics, and articulatory and acoustic phonetics.

Sharon Inkelas is Professor of Linguistics at the University of California, Berkeley, USA. She has focused since her doctoral dissertation on the interface between phonology and morphology. Her dissertation developed a new theoretical model of the interface; she has published books on reduplication (with Cheryl Zoll, in 2005) and on the phonology–morphology interface (in 2014). With Gabriela Caballero, she has worked on a new theoretical model integrating construction morphology with Optimality Theory. Her most recent research centres on child phonology and on Q Theory, a sub-segmental theory of phonological representations.

Khalil Iskarous is Associate Professor in Linguistics at the University of Southern California, USA. He is also Senior Research Scientist at Haskins Laboratories. His publications focus on speech production and the relationship of the motor, perceptual and phonological systems. He is also interested in the movement of muscular systems that resemble the tongue in their hydrostatic working, such as octopuses and worms.

Robert Kennedy is a Senior Lecturer in Linguistics at the University of California, Santa Barbara, USA. His research has focused on the typology and analysis of segmental and rhythmic alternations in reduplicative phonology, with an emphasis on interactions among stress patterns, morphological structure and allomorphic phenomena, as well as socio-phonological variation within and across the vowel systems of varieties of English, especially with respect to formant dimensions and contrasts in varieties of California English. His work has appeared in *Linguistic Inquiry*, *Phonology* and *American Speech*. He is also the author of *Phonology: A Coursebook* (Cambridge University Press, 2016), an introductory textbook for students of phonology.

Thomas Kettig is a doctoral student in the Department of Linguistics at the University of Hawai'i at Mānoa. His research interests lie at the intersection of phonetics, phonology, sociolinguistics and historical linguistics. He has investigated durational lengthening in Southern Standard British English /æ/, the production and perception of the Canadian Shift in Montreal English, and other topics regarding variation and change in the English low vowel space. His current research focuses on documenting the acoustic properties of vowels in 'Ōlelo Hawai'i, the indigenous language of the Hawaiian islands, by analysing archival radio recordings of elders from across the archipelago.

Seung Kyung Kim is a Post-doctoral Scholar in the Linguistics Department at Stanford University, California, USA. She uses behavioural experiments to examine the linguistic and cognitive mechanisms that underlie listeners' ability to perceive and understand spoken language. In particular, her research has focused on the role of phonetic variation and social information on spoken word recognition.

Young Shin Kim runs a language lab in her native hometown of Cheongju, Republic of Korea and is Secretary of International Society of English Phonetics. She holds a PhD from University College London; her thesis investigated the aerodynamic and acoustic characteristics of denasalised nasal consonants and how they are perceived by different L1 users. She taught phonetics at the same university for two years after her doctoral study. Upon returning to Korea, she has taught phonetics at Seoul National University and Chungnam National University. Her recent interest in research focuses on the teaching and learning of English intonation.

Albert Lee is an Assistant Professor at the Department of Linguistics and Modern Language Studies, the Education University of Hong Kong. His research interests lie in the phonetics of speech prosody, specifically of Japanese and Cantonese. He uses both acoustic analysis and analysis-by-synthesis in his work on speech production. Currently, his research focuses on L2 phonological acquisition, looking at how prosodic features such as quantity are acquired by learners from different L1 backgrounds.

Chin-Hui Lee is a Professor at the School of ECE, Georgia Institute of Technology, USA. Before 2001, he was in Bell Laboratories as a Distinguished Member of Technical Staff and Director of the Dialogue Systems Research Department. A Fellow of the IEEE and of ISCA, Lee has published over 500 papers and 30 patents. His h-index is 80. He was the recipient of the Bell Labs President Gold Award in 1998 and the SPS 2006 Technical Achievement Award for Exceptional Contributions to the Field of Automatic Speech Recognition. In 2012, he was awarded the ISCA Medal in scientific achievement for pioneering and seminal contributions to the principles and practice of automatic speech and speaker recognition.

Susan Lin is an Assistant Professor of Linguistics at the University of California, Berkeley, USA. Her research in phonetics focuses on speech production and articulation. She uses articulatory methods, primarily ultrasound and aerodynamics, to study speech, especially the production of complex speech sounds, the acquisition and development of speech articulation, and the phonetics of endangered and under-described languages.

Takehiko Makino is Professor of English as a Foreign Language at Chuo University, Tokyo, Japan, and has also taught English phonetics at other universities, including his *alma mater* Tokyo University of Foreign Studies. He was awarded a Certificate of Proficiency in the Phonetics of English by the IPA in 2004. His published works include the Japanese translation of Peter Ladefoged's *A Course in Phonetics* in 1999, an original textbook (in Japanese) *English Phonetics for Japanese Speakers* in 2005 and the Japanese translation of Tom McArthur's *The English Languages* in 2009. He also writes pronunciation entries in English dictionaries such as

unabridged *Kenkyusha's New English-Japanese Dictionary* (2002) as a lexicographer and Sanseido's *Grand Century English-Japanese Dictionary* (2017) as a senior editor.

Tara McAllister is an Associate Professor of Communicative Sciences and Disorders at New York University, USA. Her research focuses on the interaction between phonetic and phonological factors in child speech development and disorders. As principal investigator of the NYU Biofeedback Intervention Technology for Speech (BITS) lab, she leads an active programme of research measuring the efficacy of acoustic and ultrasound biofeedback in the treatment of persistent speech sound errors; she also oversees the development of staRt, an iOS app to make biofeedback intervention more widely accessible. McAllister's research is funded by the National Institute on Deafness and Other Communication Disorders and the American Speech-Language Hearing Foundation.

Kirsty McDougall is a Lecturer in Phonetics at the University of Cambridge, UK, and a Fellow of Selwyn College, Cambridge. Her research interests range across speaker characteristics, forensic phonetics, theories of speech production, and the phonetic realisation of varieties of English. Among other things, her forensic phonetic research has focused on speaker-characterising properties of dynamic features of speech, perceived voice similarity and its implications for voice parade construction, and the development of techniques for analysing individual differences in disfluency behaviour. She was a member of the 'DyViS' project team at the University of Cambridge, whose forensically oriented speech database has led to significant developments in the number and breadth of forensic phonetic studies carried out in recent years.

Geoffrey Meltzner is the Vice-President of Research and Technology at VocaliD. Geoff has focused his research efforts towards non-traditional speech technologies, including alaryngeal speech enhancement, silent speech recognition and stand-off speech recognition. He now leads VocaliD's research efforts towards providing personalised voices to individuals living with speechlessness and unique vocal persona to all things that talk.

Holger Mitterer is an Associate Professor at the University of Malta's Department of Cognitive Science. He obtained his Master's degree from the Universities of Bielefeld, Germany, and Leiden, the Netherlands, before doing his PhD at the Faculty for Psychology and Neuroscience at the University of Maastricht, The Netherlands. After completing his PhD in 2013, he was fortunate enough to get a position at the Max Planck Institute for Psycholinguistics in the Language Comprehension Group headed by Anne Cutler. He was Associate Editor of *Laboratory Phonology* from 2013 to 2018 and is currently the Joint Editor-in-Chief of *Language and Speech*.

Scott Moisik is an Assistant Professor at Nanyang Technological University in Singapore. He is a co-author of the book *Voice Quality: The Laryngeal Articulator Model* (Cambridge University Press, 2019). His research addresses how speech anatomy and physiology shape aspects of speech and speech sound systems, with a focus on laryngeal articulation, voice quality and phonological typology. He conducts experimental articulatory phonetic work with a range of imaging technologies (including MRI, lingual and laryngeal ultrasound, laryngoscopy, high-speed cinematography and 3D intra-oral scanning), and he also develops computational biomechanical simulations of vocal tract structures.

Peggy Mok received her PhD in Linguistics from the University of Cambridge, UK. She is an Associate Professor in the Department of Linguistics and Modern Languages at the Chinese University of Hong Kong. She studies both speech production and perception, particularly with cross-linguistic and psycholinguistic perspectives. Speech acquisition in various contexts and tone research are important themes in her work.

Christine Mooshammer is Professor of Phonetics and Phonology at the Humboldt-Universität zu Berlin, Germany, and a senior researcher at Haskins Laboratories. Her research mainly covers speech production on the segmental and prosodic level, especially the coordination of gestures and several articulators. More recently she also worked on speech errors and speech planning.

Matthew Moreland is a Lecturer in Phonetics at the University of East Anglia, UK, and freelances for Oxford Dictionaries as a pronunciation editor. He holds a PhD in Applied Linguistics and is a qualified Speech & Language Therapist and Fellow of the UK Higher Education Academy. The recipient of a student-led ‘innovative teaching’ award for his educational parodies of songs, he teaches a range of topics to student speech and language therapists and communication skills to students of several other health professions. He is the voice of several thousand words on oed.com and has been responsible for researching and compiling the Oxford English Dictionary ‘World English’ pronunciation models.

Richard Ogden is Professor of Linguistics at the University of York. His research focuses on the phonetic details of naturally occurring conversation, including turn-taking, and the phonetic implementation of social actions, combining conversation analytic and phonetic methods. He also has an interest in multimodality. He is on the editorial board of *Phonetica* and *Interactional Linguistics* and is the author of the textbook *An Introduction to English Phonetics* (Edinburgh University Press, 2017).

Rupal Patel is Professor of Speech Science and Technology at Northeastern University, Boston, USA, with joint appointments in the Khoury College of Computer Science and the Department of Communication Sciences and Disorders. Her areas of research expertise lie at the intersection of speech motor control and human–computer

interaction. Rupal is currently on leave from the University to launch VocaliD, a Voice AI company that she founded in 2014. VocaliD's award-winning technology empowers individuals living with speechlessness to be heard as themselves and brings applications that talk to life through uniquely crafted vocal persona.

Michael Proctor is a Senior Lecturer in the Department of Linguistics and a member of the Centre for Language Sciences at Macquarie University, Australia. His research focuses on speech production and perception, and phonetic characterisation of phonological behaviour, with a particular focus on fricatives and liquid consonants. He uses electromagnetic articulography, ultrasound, eye-tracking and MEG to investigate articulation, language development and speech processing in adults, children, second language learners and disordered populations. With colleagues in the Speech Production and Articulation Knowledge group at the University of Southern California, he is developing new methods of real-time magnetic resonance imaging to examine the dynamics of speech production, to inform our knowledge of phonological structure and its cognitive representation.

Eva Reinisch is head of the Phonetics group at the Acoustics Research Institute of the Austrian Academy of Sciences. Her research covers a variety of issues in spoken language processing. Among others, these concern signal-driven context effects on spoken word recognition, organisation of the mental lexicon, use of acoustic cues in native and non-native language processing, and the influence of foreign accent and dialect in spoken word recognition. She uses online and offline psycholinguistic methods including eye-tracking, the method whose application and merits she discusses in Chapter 18 of the current volume.

Yvan Rose is a Professor and researcher in linguistics (phonetics and phonology) who specialises in language acquisition and speech disorders at Memorial University of Newfoundland, Canada. He obtained his PhD from McGill University in 2001 and pursued additional training as post-doctoral fellow at the University of California, Berkeley as well as Brown University, USA. His research focuses on the integration of perceptual, acoustic and articulatory factors within theoretical models of phonology and phonological development. He has also contributed to the expansion of research methods in these areas through the development of Phon, an open-source software program for the study of phonology and acoustic phonetics, and the creation of the PhonBank, a web-accessible database documenting language acquisition and speech disorders across a wide range of languages and language learning contexts.

Sabato Marco Siniscalchi is a Professor at the Kore University of Enna, Italy, and an affiliate faculty with the Georgia Institute of Technology, USA. In 2006, he was engaged as a Post-Doctoral Fellow at the Georgia Institute of Technology. From 2007 to 2009, he joined the Norwegian

University of Science and Technology (NTNU), Norway, as a Research Scientist. In October 2017, while on a one-year leave from his academic appointment, he joined the Siri Speech Group, Apple Inc., Cupertino CA, USA as Senior Speech Researcher. He has acted as an associate editor in *IEEE/ACM Transactions on Audio, Speech and Language Processing* (2015–2019). He is an elected member of the IEEE Speech and Language Technical Committee (2019–2021).

Meghan Sumner is an Associate Professor in the Department of Linguistics at Stanford University, California, USA. She conducts research examining the representations and mechanisms listeners use to understand spoken language, and how linguistic and social factors affect speech perception and word recognition. Currently, she is working on a theory of the socially weighted encoding of spoken words and testing the predictions of that theory.

Beatrice Szczepek Reed is Professor of Language and Education at King's College London, UK, where she is the co-director of the Centre for Language, Discourse and Communication. Much of her research is in the area of the phonetic and prosodic features of naturally occurring talk. She is the author of the textbook *Analysing Conversation. An Introduction to Prosody* (Palgrave Macmillan, 2011) and the monograph *Prosodic Orientation in English Conversation* (Palgrave Macmillan, 2006), and she co-edited the volume *Prosody and Phonetics in Interaction* (with Dagmar Barth-Weingarten, Verlag für Gesprächsforschung, 2014). She is also the author of over forty publications on naturally occurring interaction and the prosody of everyday talk.

Markus Toman is a Head of Research & Development at VocaliD. Previously working on statistical parametric speech synthesis for the visually impaired and for transformation of language varieties, he now focuses on deep learning techniques to achieve flexible and personalised speech synthesis. His interests also include performance optimisation to bring text-to-speech systems to low-end and mobile devices and detection of artificial speech.

Natasha Warner is a Professor in Linguistics at the University of Arizona, USA. Her research is divided into two areas: phonetics/psycholinguistics/experimental phonology, and language revitalisation. In phonetics, her main interest is production and perception of reduced, spontaneous speech. In language revitalisation, she works with the dormant Mutsun language of California (Southern Costanoan) on reclaiming the spoken language through learning from archival materials, primarily from J.P. Harrington. She has worked with Mutsun community members on publishing a dictionary and on language learning materials.

Paul Warren is Professor of Linguistics in the School of Linguistics and Applied Language Studies at Victoria University of Wellington, New Zealand. Paul's research and teaching interests cover a number of areas in psycholinguistics, phonetics and phonology, including

intonation, the links between prosody and sentence processing, and the pronunciation of New Zealand English. He is the author of *Introducing Psycholinguistics* (2012) and *Uptalk: The Phenomenon of Rising Intonation* (2016), both published by Cambridge University Press.

Jarosław Weckwerth is Senior Lecturer in the Faculty of English, Adam Mickiewicz University, Poznań, Poland. His research interests include phonetics, sociolinguistics and the use of technology in the teaching of linguistics. He has published work on various aspects of Polish and English phonetics and phonology, such as the spectral characteristics of Polish and English vowels, acquisition of L2 phonology, and pronunciation models in EFL.

Nicole Whitworth is the Head of the Department of Languages at Leeds Beckett University, UK. She has extensive experience in teaching phonetics, phonology and anatomy to students on qualifying Speech and Language Therapy courses. Nicole is a Fellow of the Higher Education Academy. She is the co-editor (with Rachael-Anne Knight) of *Methods in Teaching Clinical Phonetics and Linguistics* (J&R Press, 2014). Her research centres around the acquisition of speech in bilingual children and adults and in young children with Down Syndrome.

Francis C. K. Wong is an Assistant Professor in the School of Humanities at Nanyang Technological University, Singapore. His research interests include cognitive neuroscience, speech perception and communication disorders. His current research focuses on employing brain imaging techniques and artificial language learning paradigms to study how speech processing is supported by a network of brain areas, as well as developing an audiological rehabilitation programme for speech perception in noise difficulty.

Patrick C. M. Wong is the Stanley Ho Chair in Cognitive Neuroscience, Professor of Linguistics and Founding Director of the Brain and Mind Institute at the Chinese University of Hong Kong. As a cognitive neuroscientist, linguist and speech-language pathologist, Wong's research covers a wide range of basic and translational issues concerning the neural basis and disorders of language and music. His research has appeared in a broad array of interdisciplinary scholarly venues including *Nature Neuroscience* and *Proceedings of the National Academy of Sciences*. Wong's research has also received public attention from media outlets such as *The New York Times* and the British Broadcasting Corporation/Public Radio International.

Alan Wrench is Director of Articulate Instruments Ltd, a company specialising in development and provision of ultrasound and other instrumentation designed for speech analysis. He is also a consultant professor at Queen Margaret University, Edinburgh, UK. His current research interests include investigation of neuromuscular control of movement and the mechanisms facilitating motor learning and performance, by