ARTICULATORY PHONETICS

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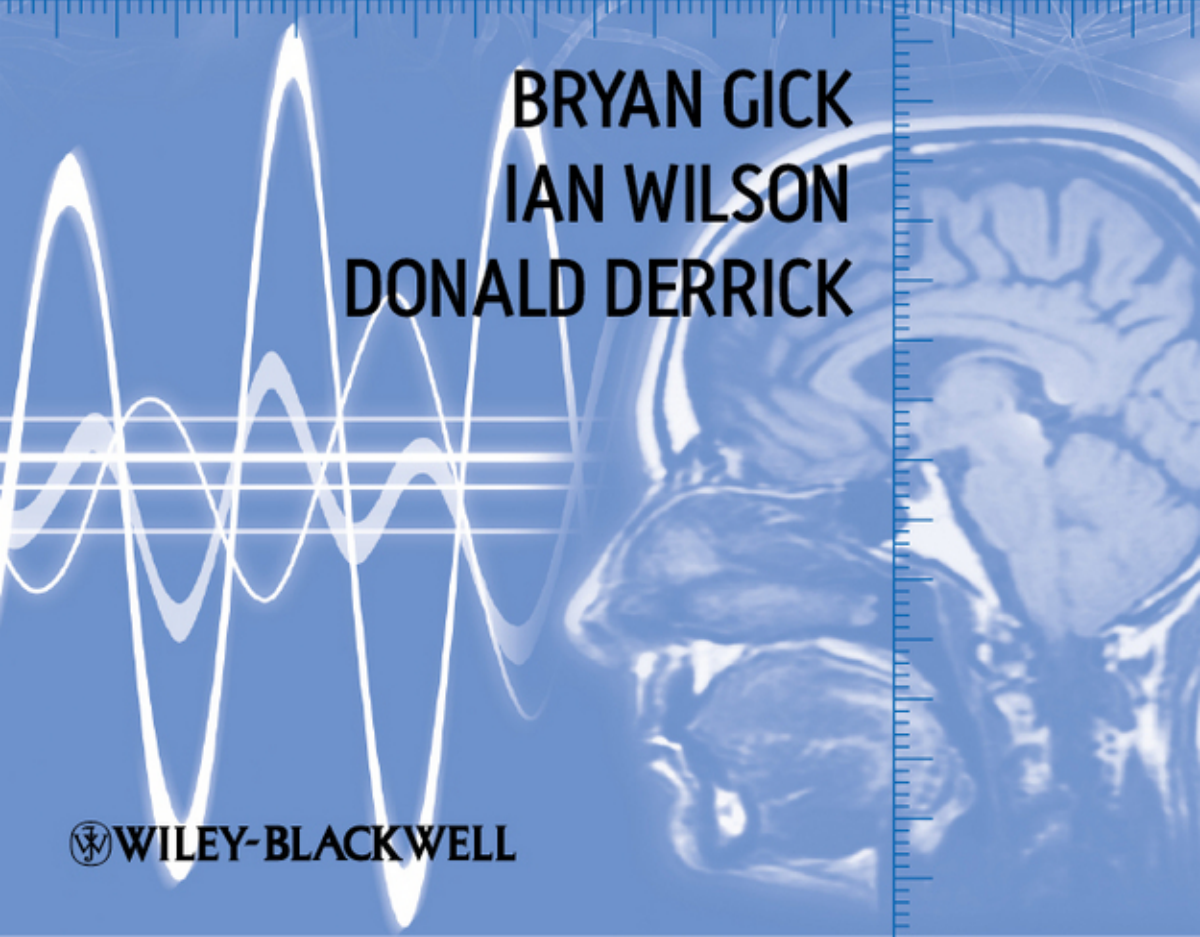

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Praise for *Articulatory Phonetics*

"Life has just become less lonely for Acoustic and Auditory Phonetics. Gick, Wilson, and Derrick have given us a marvelous addition to the classroom, providing an authoritative description of speech articulation, an insightful and balanced guide to the theory of cognitive control of speech, and a highly readable introduction to the methods used in articulatory phonetics. All students of phonetics should study this book!"

Keith Johnson, University of California, Berkeley

"Gick, Wilson, and Derrick offer an engaging, comprehensive introduction to how articulation works and how it is investigated in the laboratory. This textbook fills an important gap in our training of phoneticians and speech scientists."

Patrice Beddor, University of Michigan

"A rich yet approachable source of phonetic information, this new text is well structured, well designed, and full of original diagrams."

James Scobbie, Queen Margaret University

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Bryan Gick, Ian Wilson,
and Donald Derrick

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At many junctures in this book there simply were not satisfying answers to even quite basic questions. As such, we have done a good deal of original research to confirm or underscore many points in this book. Part of this research was funded by a Discovery Grant from the Natural Sciences and Engineering Council of Canada (NSERC) to Bryan Gick, by National Institutes of Health (NIH) Grant DC-02717 to Haskins Laboratories, and by Japan Society for the Promotion of Science (JSPS) "kakenhi" grant 19520355 to Ian Wilson.

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Introduction

The goal of this book is to provide a short, non-technical introduction to articulatory phonetics. We focus especially on (1) the basic anatomy and physiology of speech, (2) how different kinds of speech sounds are made, and (3) how to measure the vocal tract to learn about these speech sounds. This book was conceived of and written to function as a companion to Keith Johnson's *Acoustic and Auditory Phonetics* (also published by Wiley-Blackwell). It is intended as a supplement or follow-up to a general introduction to phonetics or speech science for students of linguistic phonetics, speech science, and the psychology of speech.

Part I of this book, entitled "Getting to Sounds," leads the reader through the speech production system up to the point where simple vocal sounds are produced. Chapter 1 introduces the speech chain and basic terms and concepts that will be useful in the rest of the book; this chapter also introduces anatomical terminology and an overview of tools used to measure anatomy. Chapters 2 and 3 walk the reader from thought to action, starting with the brain in Chapter 2, following through the peripheral nervous system and ending with muscle movement in Chapter 3. Chapter 4 continues from muscle action to airflow, describing respiratory anatomy and physiology. Chapter 5 moves from airflow to sound by describing laryngeal anatomy and physiology and introducing basic phonation.

Part II, entitled "Articulating Sounds," continues through the speech system, introducing more anatomy and tools along the way, but giving more focus to particular sounds of speech. Chapter 6 introduces more advanced phonation types and airstream mechanisms, and describes the hyoid bone and supporting muscles. Chapter 7 introduces the nasopharynx, skull, and palate, and the sphincter mechanisms that allow the description of velic sounds. Chapter 8 describes how vowel sounds are made, introducing the jaw and jaw muscles, and the extrinsic muscles of

the tongue, with special emphasis on hydrostatics and the inverse problem of speech. Chapter 9 describes how lingual consonant sounds are made, introducing the intrinsic muscles of the tongue and the concepts of ballistics, overshoot, and constriction degree and location. Chapter 10 covers labial sounds, introducing lip and face anatomy and the visual modality in speech. Chapter 11 wraps up by considering what happens when we combine the articulations discussed throughout the book. It starts by talking about context-sensitive versus context-invariant models of coordinating sounds, describes complex sounds including liquids and clicks, and finishes with coarticulation. At the very end of the book, there is a list of all abbreviations used, as well as a table of muscles with their innervations and attachment points. While this book follows a logical flow, it is possible to cover some parts in a different order. In particular, Chapter 2, which deals with the brain, is designed so that it can be read either in the order presented, or at the end of the book.

While there is very little math in this textbook, many of the questions and assignments at the end of each chapter and in the online material (www.wiley.com/go/articulatoryphonetics) require making measurements, and often require a basic knowledge of descriptive statistics and the use of t-tests. Students who study articulatory phonetics are strongly encouraged to study statistics for psychological or motor behavior experiments, as our field often requires the use of more complex statistics such as those offered in more advanced courses.

One important note about this book: some traditions identify articulatory phonetics with a general description of how sounds are made, or with a focus on recognizing, producing or transcribing sounds using systems such as the International Phonetic Alphabet (IPA). We do not. Rather, this textbook sets out to give students the basic content and conceptual grounding they will need to understand how articulation works, and to navigate the kinds of research conducted by practitioners in the field of articulatory phonetics. IPA symbols are used throughout the text, and students are expected to use other sources to learn how to pronounce such sounds and transcribe acoustic data.

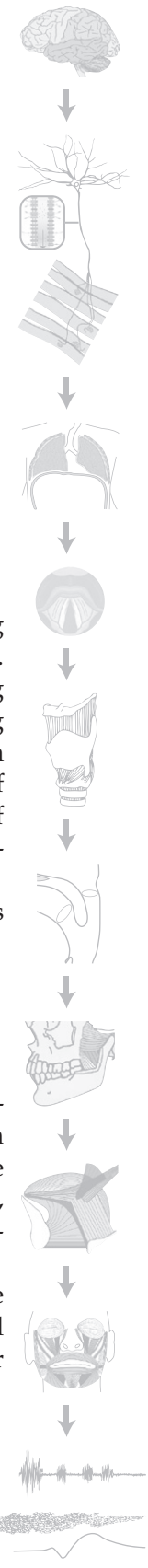
Semi-related stuff in boxes

Our textbook includes semi-related topics in gray boxes. These boxes give us a place to point out some of the many interesting side notes relating to articulatory phonetics that we would otherwise not have the space to cover. Don't be surprised if you find that the boxes contain some of the most interesting material in this book.

Part I
Getting to Sounds

Chapter 1

The Speech System and Basic Anatomy



Sound is movement. You can see or feel an object even if it – and everything around it – is perfectly still, but you can only hear an object when it moves. When things move, they sometimes create disturbances in the surrounding air that can, in turn, move the eardrum, giving us the sensation of hearing (Keith Johnson's *Acoustic and Auditory Phonetics* discusses this topic in detail). In order to understand the sounds of speech (the central goal of phonetics as a whole), we must first understand how the different parts of the human body move to produce those sounds (the central goal of articulatory phonetics).

This chapter describes the roadmap we follow in this book, as well as some of the background basics you'll need to know.

1.1 The Speech Chain

Traditionally, scientists have described the process of producing and perceiving speech in terms of a mostly feed-forward system, represented by a linear speech chain (Denes and Pinson, 1993). A *feed-forward* system is one in which a plan (in this case a speech plan) is constructed and carried out, without paying attention to the results. If you were to draw a map of a feed-forward system, all the arrows would go in one direction (see Figure 1.1).

Thus, in a feed-forward *speech chain* model, a speaker's thoughts are converted into linguistic representations, which are organized into vocal tract movements – *articulations* – that produce acoustic output. A listener

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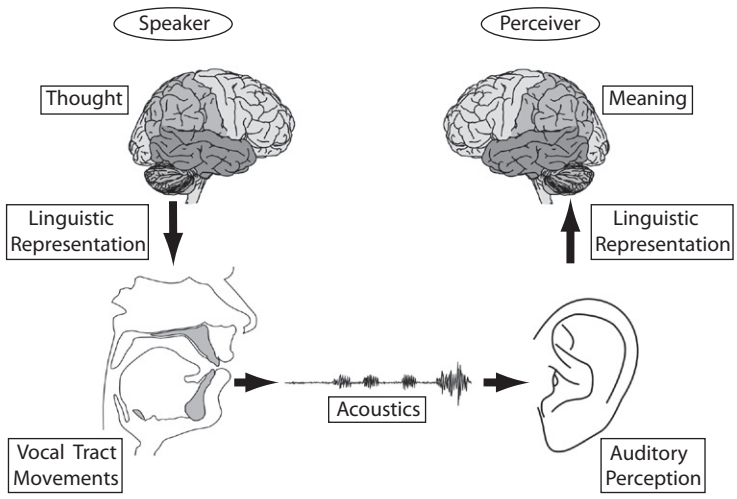

Figure 1.1 Feed-forward, auditory-only speech chain (image by W. Murphey and A. Yeung).

can then pick up this acoustic signal through hearing, or *audition*, after which it is perceived by the brain, converted into abstract linguistic representations and, finally, meaning.

Although the simplicity of a feed-forward model is appealing, we know that producing speech is not strictly linear and unidirectional. Rather, when we speak, we are also constantly monitoring and adjusting what we're doing as we move along the chain. We do this by using our senses to perceive what we are doing. This is called *feedback*. In a feedback system, control is based on observed results, rather than on a predetermined plan. The relationship between feedforward and feedback control in speech is complex. Also, speech perception feedback is *multimodal*. That is, we use not just our sense of hearing when we perceive and produce speech, but all of our sense modalities – even some you may not have heard of before. Thus, while the speech chain as a whole is generally linear, each link in the chain – and each step in the process of speech communication – is a loop (see Figure 1.2). We can think of each link of the chain as a *feedback loop*.

Multimodality and feedback

Speech production uses many different sensory mechanisms for feedback. The most commonly known feedback in speech is auditory feedback, though many senses are important in providing feedback in speech.

(Continued)