

Contents

Acknowledgments	viii
Introduction	1
Part I Fundamentals	5
1 Basic Acoustics and Acoustic Filters	7
1.1 The Sensation of Sound	7
1.2 The Propagation of Sound	8
1.3 Types of Sounds	11
1.3.1 <i>Simple periodic waves</i>	11
1.3.2 <i>Complex periodic waves</i>	12
1.3.3 <i>Aperiodic waves</i>	17
1.4 Acoustic Filters	19
Recommended Reading	22
Exercises	23
2 The Acoustic Theory of Speech Production: Deriving Schwa	25
2.1 Voicing	25
2.2 Voicing Quanta	28
2.3 Vocal Tract Filtering	30
2.4 Pendulums, Standing Waves, and Vowel Formants	32
2.5 Discovering Nodes and Antinodes in an Acoustic Tube	45
Recommended Reading	47
Exercises	48

3 Digital Signal Processing	49
3.1 Continuous versus Discrete Signals	49
3.2 Analog-to-Digital Conversion	50
3.2.1 <i>Sampling</i>	51
3.2.2 <i>Quantization</i>	55
3.3 Signal Analysis Methods	59
3.3.1 <i>RMS amplitude</i>	59
3.3.2 <i>Fast Fourier transform (FFT)</i>	60
3.3.3 <i>Auto-correlation pitch tracking</i>	64
3.3.4 <i>Digital filters</i>	68
3.3.5 <i>Linear predictive coding (LPC)</i>	71
3.3.6 <i>Spectra and spectrograms</i>	77
Recommended Reading	79
Exercises	80
4 Basic Audition	82
4.1 Anatomy of the Peripheral Auditory System	82
4.2 The Auditory Sensation of Loudness	83
4.3 Frequency Response of the Auditory System	88
4.4 Saturation and Masking	90
4.5 Auditory Representations	93
Recommended Reading	97
Exercises	98
5 Speech Perception	100
5.1 Auditory Ability Shapes Speech Perception	101
5.2 Phonetic Knowledge Shapes Speech Perception	104
5.2.1 <i>Categorical perception</i>	104
5.2.2 <i>Phonetic coherence</i>	109
5.3 Linguistic Knowledge Shapes Speech Perception	112
5.4 Perceptual Similarity	115
5.4.1 <i>Maps from distances</i>	116
5.4.2 <i>The perceptual map of fricatives</i>	119
Recommended Reading	124
Exercises	126
Part II Speech Analysis	129
6 Vowels	131
6.1 Tube Models of Vowel Production	131
6.2 Perturbation Theory	137
6.3 “Preferred” Vowels – Quantal Theory and Adaptive Dispersion	141

6.4	Vowel Formants and the Acoustic Vowel Space	142
6.5	Auditory and Acoustic Representations of Vowels	144
6.6	Cross-linguistic Vowel Perception	146
	Recommended Reading	149
	Exercises	150
7	Fricatives	152
7.1	Turbulence	152
7.2	Place of Articulation in Fricatives	157
7.3	Quantal Theory and Fricatives	159
7.4	Fricative Auditory Spectra	162
7.5	Dimensions of Fricative Perception	165
	Recommended Reading	166
	Exercises	167
8	Stops and Affricates	169
8.1	Source Functions For Stops and Affricates	170
8.1.1	<i>Phonation types</i>	170
8.1.2	<i>Sound sources in stops and affricates</i>	172
8.2	Vocal Tract Filter Functions in Stops	176
8.3	Affricates	179
8.4	Auditory Properties of Stops	180
8.5	Stop Perception in Different Vowel Contexts	182
	Recommended Reading	183
	Exercises	184
9	Nasals and Laterals	185
9.1	Bandwidth	185
9.2	Nasal Stops	187
9.3	Laterals	196
9.4	Nasalization	198
9.5	Nasal Consonant Perception	202
	Recommended Reading	204
	Exercises	205
	References	206
	Answers to Selected Short-answer Questions	212
	Index	218