

Contents

List of Abbreviations	XXIX
1 Systematic Musicology: A Historical Interdisciplinary Perspective	
<i>Albrecht Schneider</i>	1
1.1 Systematic Musicology: Discipline and Field of Research	1
1.2 Beginnings of Music Theory in Greek Antiquity	2
1.3 From the Middle Ages to the Renaissance and Beyond: Developments in Music Theory and Growth of Empiricism	3
1.4 Sauveur, Rameau and the Issue of <i>Physicalism</i> in Music Theory	5
1.5 Concepts of Systems and Systematic Research	7
1.6 Systematic Approaches: Chladni, Helmholtz, Stumpf, and Riemann	9
1.7 Gestalt Quality and Gestalt Psychology	12
1.8 Music Psychology: Individual and Sociocultural Factors	14
1.9 Some Modern Developments	15
1.10 Systematic Musicology as a Musicological Discipline	17
References	19
Part A Musical Acoustics and Signal Processing	
2 Vibrations and Waves	
<i>Wilfried Kausel</i>	29
2.1 Vibrations	29
2.2 Waves.....	33
2.3 Wave Equations 1-D	36
2.4 Solution for 1-D-Waves	40
2.5 Stiffness	46
References	46
3 Waves in Two and Three Dimensions	
<i>Wilfried Kausel</i>	49
3.1 Waves on a Surface.....	49
3.2 Solution for Waves on a Surface.....	52
3.3 Sound Waves in Space	56
References	62
4 Construction of Wooden Musical Instruments	
<i>Chris Waltham, Shigeru Yoshikawa</i>	63
4.1 Scope	63
4.2 Physical Properties of Wood	65
4.3 Tonewoods	68
4.4 Framewoods	72
4.5 Construction	74
4.6 Conclusion	78
4.A Appendix.....	78
References	78

5 Measurement Techniques	
<i>Thomas Moore</i>	81
5.1 Measurement of Airborne Sound	81
5.2 Measurement of Deflection	87
5.3 Measurement of Impedance	99
5.4 Conclusions	101
References	101
6 Some Observations on the Physics of Stringed Instruments	
<i>Nicholas Giordano</i>	105
6.1 Three Classes of Stringed Instruments	105
6.2 Common Components and Issues	105
6.3 The Story of Three Instruments	108
6.4 Summary	117
References	118
7 Modeling of Wind Instruments	
<i>Benoit Fabre, Joël Gilbert, Avraham Hirschberg</i>	121
7.1 A Classification of Wind Instruments	121
7.2 The Clarinet	123
7.3 The Oboe	128
7.4 The Harmonica	130
7.5 The Trombone	131
7.6 The Flute	133
References	137
8 Properties of the Sound of Flue Organ Pipes	
<i>Judit Angster, András Miklós</i>	141
8.1 Experimental Methodology	142
8.2 Steady-Sound Characteristics	142
8.3 Edge and Mouth Tones	149
8.4 Characteristics of the Attack Transients	151
8.5 Discussion and Outlook	153
References	154
9 Percussion Musical Instruments	
<i>Andrew C. Morrison, Thomas D. Rossing</i>	157
9.1 Drums	157
9.2 Mallet Percussion Instruments	160
9.3 Cymbals, Gongs, and Plates	164
9.4 Methods for Studying the Acoustics of Percussion Instruments	168
References	170
10 Musical Instruments as Synchronized Systems	
<i>Rolf Bader</i>	171
10.1 Added versus Intrinsic Synchronization	171
10.2 Models of the Singing Voice	173
10.3 Harmonic Synchronization in Wind Instruments	178
10.4 Violin Bow-String Interaction	182
10.5 Fractal Dimensions of Musical Instrument Sounds	186
10.6 General Models of Musical Instruments	191
10.7 Conclusions	194
References	195

11 Room Acoustics – Fundamentals and Computer Simulation	
<i>Michael Vorländer</i>	197
11.1 Fundamentals of Sound Fields in Rooms.....	198
11.2 Statistical Room Acoustics	199
11.3 Reverberation.....	200
11.4 Stationary Excitation	201
11.5 Room Impulse Responses.....	201
11.6 Computers in Room Acoustics	206
11.7 Auralization	211
11.8 Current Research Topics	212
11.9 Final Remarks.....	213
References	214

Part B Signal Processing

12 Music Studio Technology	
<i>Robert Mores</i>	221
12.1 Microphones and Microphone Arrangements.....	222
12.2 Signal Preconditioning and Effects	227
12.3 Digitalization	232
12.4 Mixing Consoles	235
12.5 Synthesizer and Sequencer.....	236
12.6 Historical and Contemporary Audio Formats and Restoration	239
12.7 Signals, Connectors, Cables and Audio Networks.....	245
12.8 Loudspeakers, Reference Listening and Reinforcement.....	251
References	257
13 Delay-Lines and Digital Waveguides	
<i>Gary Scavone</i>	259
13.1 Digital Delay Lines.....	259
13.2 Simulating Sound Wave Propagation	264
13.3 Digital Waveguides	267
References	271
14 Convolution, Fourier Analysis, Cross-Correlation and Their Interrelationship	
<i>Jonas Braasch</i>	273
14.1 Convolution	273
14.2 Fourier Frequency Analysis and Transformation	276
14.3 Cross-Correlation	280
References	284
15 Audio Source Separation in a Musical Context	
<i>Bryan Pardo, Zafar Rafii, Zhiyao Duan</i>	285
15.1 REPET	286
15.2 Pitch-Based Source Separation.....	291
15.3 Leveraging the Musical Score	294
15.4 Conclusions	296
References	297

16 Automatic Score Extraction with Optical Music Recognition (OMR)	
<i>Ichiro Fujinaga, Andrew Hankinson, Laurent Pugin</i>	299
16.1 History.....	299
16.2 Overview	300
16.3 OMR Challenges.....	301
16.4 Technical Background	302
16.5 Adaptive OMR.....	305
16.6 Symbolic Music Encoding	305
16.7 Tools	307
16.8 Future	308
References	309
17 Adaptive Musical Control of Time-Frequency Representations	
<i>Doug Van Nort, Phillippe Depalle</i>	313
17.1 State-Space Analysis/Synthesis.....	314
17.2 Recursive, Infinite-Length Windows.....	316
17.3 Kalman Filter-Based Phase Vocoder	317
17.4 Additive Layer and Higher-Level Architecture.....	318
17.5 Sound Transformations	319
17.6 Adaptive Control of Sound Transformations	320
17.7 Chapter Summary	325
17.A Appendix 1: Chandrasekhar Implementation.....	325
17.B Appendix 2: Example 2 EKF Derivation	326
References	327
18 Wave Field Synthesis	
<i>Tim Ziemer</i>	329
18.1 Overview	329
18.2 Wave Equation and Solutions	330
18.3 Wave Front Synthesis.....	336
18.4 Current Research and Development	343
References	345
19 Finite-Difference Schemes in Musical Acoustics: A Tutorial	
<i>Stefan Bilbao, Brian Hamilton, Reginald Harrison, Alberto Torin</i>	349
19.1 The 1-D Wave Equation.....	350
19.2 The Ideal Bar Equation.....	356
19.3 Acoustic Tubes	360
19.4 The 2-D and 3-D Wave Equations	364
19.5 Thin Linear Plate Vibration	377
19.6 Extensions to Nonlinear Systems.....	381
References	381
20 Real-Time Signal Processing on Field Programmable Gate Array Hardware	
<i>Florian Pfeifle</i>	385
20.1 Overview	386
20.2 Digital Binary Logic.....	388
20.3 FPGA – A Structural Overview.....	390

20.4	Hardware Description Language (HDL).....	394
20.5	FPGA Hardware Overview	397
20.6	FPGA Chips	397
20.7	Interfacing With a FPGA.....	399
20.8	Real-Time DSP Applications	402
20.9	Real-Time Filtering Applications	402
20.10	Real-Time Physical Modeling of Large-Scale Geometries	405
20.11	Summary and Outlook	414
	References	415

Part C Music Psychology – Physiology

21 Auditory Time Perception		
	<i>Simon Grondin, Emi Hasuo, Tsuyoshi Kuroda, Yoshitaka Nakajima</i>	423
21.1	Methods for Studying Interval Processing	424
21.2	Processing Time Intervals: Variability.....	425
21.3	Processing Time Intervals: Perceived Duration.....	429
21.4	Theoretical Perspectives	434
21.5	Conclusion	435
	References	435
22 Automatic Processing of Musical Sounds in the Human Brain		
	<i>Elvira Brattico, Chiara Olcese, Mari Tervaniemi</i>	441
22.1	Perceiving the Music Around Us: An Attentive or Automatic Process?	441
22.2	The MMN as a Measure of Automatic Sound Processing in the Auditory Cortex.....	442
22.3	Neural Generators of the MMN	443
22.4	The MMN for Studying Automatic Processing of Simple Musical Rules	444
22.5	ERAN as an Index of Semiautomatic Processing of Musical Rules ...	445
22.6	Environmental Exposure Modulates the Automatic Neural Representations of Musical Sounds	445
22.7	Disrupted Automatic Discrimination of Musical Sounds.....	446
22.8	Conclusions	448
	References	448
23 Long-Term Memory for Music		
	<i>Lola L. Cuddy</i>	453
23.1	Long-Term Memory and the Semantic System	453
23.2	Semantic Memory for Music	454
23.3	Evidence from Neuropsychology	455
23.4	Concluding Comments	457
	References	458
24 Auditory Working Memory		
	<i>Katrin Schulze, Stefan Koelsch, Victoria Williamson</i>	461
24.1	The Baddeley and Hitch WM Model: Theoretical Considerations and Empirical Support	461
24.2	WM: Behavioral Data	462

24.3	Neural Correlates Underlying WM	464
24.4	Sensorimotor Codes – Auditory WM and the Motor System.....	466
24.5	The Influence of LTM on Auditory WM Performance	468
24.6	Summary and Conclusion.....	468
	References	469
25	Musical Syntax I: Theoretical Perspectives	
	<i>Martin Rohrmeier, Marcus Pearce</i>	473
25.1	Outline	473
25.2	Theories of Musical Syntax.....	474
25.3	Models of Musical Syntax	477
25.4	Syntactic Models of Different Complexity	478
25.5	Discussion	482
25.A	Appendix: The Chomsky Hierarchy	483
	References	483
26	Musical Syntax II: Empirical Perspectives	
	<i>Marcus Pearce, Martin Rohrmeier</i>	487
26.1	Computational Research	487
26.2	Psychological Research.....	494
26.3	Neuroscientific Research	496
26.4	Implications and Issues.....	498
	References	499
27	Rhythm and Beat Perception	
	<i>Tram Nguyen, Aaron Gibbings, Jessica Grahn</i>	507
27.1	Temporal Regularity and Beat Perception	507
27.2	Behavioral Investigations.....	508
27.3	Electrophysiological Investigations	509
27.4	Hemodynamic (fMRI/PET) Investigations.....	514
27.5	Patient and Brain Stimulation Investigations.....	515
27.6	Discussion	516
	References	517
28	Music and Action	
	<i>Giacomo Novembre, Peter E. Keller</i>	523
28.1	Coupling Action and Perception Through Musical Experience	524
28.2	Responding to Music with Action and (Social) Interaction.....	528
28.3	Conclusion and Perspectives	534
	References	534
29	Music and Emotions	
	<i>Tuomas Eerola</i>	539
29.1	The Rise of Music and Emotion Research	539
29.2	Structure of Emotions	540
29.3	Mechanisms and Modifiers of Emotions.....	543
29.4	Measures and Musical Materials	547
29.5	Current Challenges	549
	References	550

Part D Psychophysics/Psychoacoustics

30 Fundamentals	
<i>Albrecht Schneider</i>	559
30.1 Theoretical and Methodological Background	560
30.2 Types of Sound and Sound Features Relevant for Hearing and Music Perception	587
30.3 Some Basics of Sound in a Sound Field	596
References	598
31 Pitch and Pitch Perception	
<i>Albrecht Schneider</i>	605
31.1 Pitch as Elementary Sensation and as Perceptual Quality	606
31.2 Sketch of the Auditory Pathway (AuP)	615
31.3 Excitation of the Auditory System: From the Tympanum to the BM, the IHC and OHC	617
31.4 Place Coding and Temporal Coding of Sound Features	620
31.5 Auditory Models and Pitch Extraction	627
31.6 Psychophysics.....	629
31.7 Categorical Pitch Perception, Relative and Absolute Pitch	640
31.8 Scales, Tone Systems, Aspects of Intonation	651
31.9 Geometric Pitch Models, Tonality	663
References	671
32 Perception of <i>Timbre</i> and <i>Sound Color</i>	
<i>Albrecht Schneider</i>	687
32.1 <i>Timbre</i> and <i>Sound Color</i> : Basic Features.....	687
32.2 Sensation and Perception of <i>Timbre</i> and <i>Sound Color</i>	695
References	719
33 Sensation of Sound Intensity and Perception of Loudness	
<i>Albrecht Schneider</i>	727
33.1 Physical and Physiological Basis of Sound Intensity Sensation.....	727
33.2 Models of Loudness Sensation	730
33.3 From Lab to Disco: Measurements and Perceptual Variability of Loudness	735
33.4 Summing up	737
References	739

Part E Music Embodiment

34 What Is Embodied Music Cognition?	
<i>Marc Leman, Pieter-Jan Maes, Luc Nijs, Edith Van Dyck</i>	747
34.1 Ontological and Epistemological Foundations	748
34.2 The Architecture of Embodied Music Cognition	750
34.3 Empirical Evidence for Embodied Music Cognition	753
34.4 Embodiment and Dynamic Cognition.....	756
34.5 Contributions to a Paradigm Shift in Systematic Musicology	757
34.6 Conclusion	757
References	758

35 Sonic Object Cognition	
<i>Rolf Inge Godøy</i>	761
35.1 Object Focus	761
35.2 Ontologies.....	763
35.3 Motor Theory.....	764
35.4 Timescales and Duration Thresholds.....	765
35.5 Chunking.....	766
35.6 Sound Generation	767
35.7 Constraints and Idioms	768
35.8 Sound Synthesis	769
35.9 Feature Taxonomy	770
35.10 Shape Cognition	771
35.11 Typology and Morphology of Sonic Objects	772
35.12 Singular, Composed, Composite and Concatenated Objects	773
35.13 Textures, Hierarchies, Roles and Translations	774
35.14 Analysis-by-Synthesis	775
35.15 Summary	776
References	776
36 Investigating Embodied Music Cognition for Health and Well-Being	
<i>Micheline Lesaffre</i>	779
36.1 Transitions in Musicology and Society	779
36.2 Models of Music, Health and Well-Being	781
36.3 From Theory to Therapeutic Approaches	783
36.4 Conclusion	789
References	789
37 A Conceptual Framework for Music-Based Interaction Systems	
<i>Pieter-Jan Maes, Luc Nijs, Marc Leman</i>	793
37.1 A Conceptual Model of Music-Based Interaction Systems.....	794
37.2 The Human Reward System.....	795
37.3 Social Interaction.....	797
37.4 Monitoring, Motivation, and Alteration	797
37.5 The Evaluation of Music-Based Interactive Systems	799
37.6 Some Case Studies of Applications and Supporting Research.....	799
37.7 Conclusion	801
References	802
38 Methods for Studying Music-Related Body Motion	
<i>Alexander Refsum Jensenius</i>	805
38.1 Some Key Challenges	805
38.2 Qualitative Motion Analysis.....	806
38.3 Video-Based Analyses	808
38.4 Sensor-Based Motion Capture	812
38.5 Synchronization and Storage	815
38.6 Conclusion	816
References	816

Part F Music and Media

39 Content-Based Methods for Knowledge Discovery in Music	
<i>Juan Pablo Bello, Peter Grosche, Meinard Müller, Ron Weiss</i>	823
39.1 Music Structure Analysis	824
39.2 Feature Representation	826
39.3 Music Synchronization and Navigation	827
39.4 Self-Similarity in Music Recordings	829
39.5 Automated Extraction of Repetitive Structures.....	835
39.6 Conclusions	838
References	838
40 Hearing Aids and Music: Some Theoretical and Practical Issues	
<i>Marshall Chasin, Neil S. Hockley</i>	841
40.1 Assessment of Musicians.....	842
40.2 Peripheral Sensory Hearing Loss	842
40.3 Direct Assessment of Music with a Peripheral Hearing Loss.....	844
40.4 Acoustic Properties of Music versus Speech	844
40.5 Some Strategies to Handle the More Intense Inputs of Music	846
40.6 Some Hearing-Aid Technologies to Handle the More Intense Inputs of Music.....	847
40.7 General Recommendations for an Optimal Hearing Aid for Music	849
40.8 Conclusions and Recommendations for Further Research	851
References	851
41 Music Technology and Education	
<i>Estefanía Cano, Christian Dittmar, Jakob Abeßer, Christian Kehling, Sascha Grollmisch</i>	855
41.1 Background	856
41.2 Music Education Tools.....	857
41.3 Sound Source Separation for the Creation of Music Practice Material	859
41.4 Drum Transcription for Real-Time Music Practice	862
41.5 Guitar Transcription Beyond Score Notation	865
41.6 Discussion and Future Challenges	868
References	869
42 Music Learning: Automatic Music Composition and Singing Voice Assessment	
<i>Lorenzo J. Tardón, Isabel Barbancho, Carles Roig, Emilio Molina, Ana M. Barbancho</i>	873
42.1 Related Work on Melody Composition	874
42.2 Related Work on Voice Analysis for Assessment	874
42.3 Music Composition for Singing Assessment	875
42.4 Singing Assessment	879
42.5 Summary	881
References	882

43 Computational Ethnomusicology: A Study of Flamenco and Arab-Andalusian Vocal Music	
<i>Nadine Kroher, Emilia Gómez, Amin Chaachoo, Mohamed Sordo, José-Miguel Díaz-Báñez, Francisco Gómez, Joaquin Mora</i>	885
43.1 Motivation	885
43.2 Background	887
43.3 Case Study.....	889
43.4 Conclusion and Future Perspectives	895
43.5 Complementary Material.....	896
References	896
44 The Relation Between Music Technology and Music Industry	
<i>Alexander Lerch</i>	899
44.1 Recording and Performance	901
44.2 Music Creation	903
44.3 Music Distribution and Consumption	906
44.4 Conclusion	907
References	908
45 Enabling Interactive and Interoperable Semantic Music Applications	
<i>Jesús Corral García, Panos Kudumakis, Isabel Barbancho, Lorenzo J. Tardón, Mark Sandler</i>	911
45.1 IM AF Standard	912
45.2 Implementation of the IM AF Encoder.....	913
45.3 IM AF in Sonic Visualiser	917
45.4 Future Developments and Conclusions	920
References	920
46 Digital Sensing of Musical Instruments	
<i>Peter Driessen, George Tzanetakis</i>	923
46.1 Digital Music Instruments	923
46.2 Elements of a Hyperinstrument.....	924
46.3 Acoustic Instrument.....	924
46.4 Hyperinstrument	925
46.5 Direct Sensors.....	925
46.6 Indirect or Surrogate Sensors.....	927
46.7 Instrument Case Studies	928
46.8 Application Case Studies	930
46.9 Conclusions	932
References	932

Part G Music Ethnology

47 Interaction Between Systematic Musicology and Research on Traditional Music	
<i>Jukka Louhivuori</i>	939
47.1 Background	939
47.2 Folk/Traditional Music Research	940
47.3 Comparative Musicology	941

47.4	Cognitive Approaches – Cross-Cultural Music Cognition and Cognitive Ethnomusicology	941
47.5	Anthropology of Music – Ethnomusicology – Cultural Musicology ..	943
47.6	New Trends	945
47.7	Function of Ethnomusicology in Systematic Musicology	946
47.8	Summary	948
	References	949
48	Analytical Ethnomusicology: How We Got Out of Analysis and How to Get Back In	
	<i>Leslie Tilley</i>	953
48.1	Ethnomusicology's Analytical Roots	953
48.2	The Mid-Century Pendulum Swing: The Rise of Anthropology-Based Studies	959
48.3	Analysis in Modern Ethnomusicology	966
	References	974
49	Musical Systems of Sub-Saharan Africa	
	<i>Simha Arom</i>	979
	References	982
50	Music Among Ethnic Minorities in Southeast Asia	
	<i>Håkan Lundström</i>	987
50.1	Singing Manners	988
50.2	The Sounds of Bamboo and Metal	992
50.3	Music and Village Life	996
50.4	Village Music and Modern Society	999
50.A	Appendix: Recordings	1002
	References	1002
51	Music Archaeology	
	<i>Ricardo Eichmann</i>	1005
51.1	Methods	1006
51.2	Research Topics	1007
51.3	Musical Practice	1008
51.4	Music Theory	1009
51.5	Ancient Sounds	1010
51.6	Conclusion	1011
	References	1012
52	The Complex Dynamics of Improvisation	
	<i>David Borgo</i>	1017
52.1	The Study of Improvisation	1017
52.2	The Field of Improvisation Studies	1018
52.3	Challenges in Defining Improvisation	1018
52.4	Some Contemporary Research Directions	1020
52.5	Referent-Based Improvisation	1021
52.6	Referent-Free Improvisation	1022
52.7	Final Thoughts	1024
	References	1025

53 Music of Struggle and Protest in the 20th Century
Anthony Seeger 1029
53.1 Historical Antecedents of Music of Protest and Struggle
in the United States 1030
53.2 The Poet Walt Whitman’s Influence on the Image
of the Protest Singer–Songwriter 1031
53.3 Ballad Collectors, Songs of Struggle, and Versions
of the American Identity 1032
53.4 The Vocal Style and Performance Practice of US Protest Music 1033
53.5 20th Century Politics and Protest Music 1035
53.6 African–American Musical Traditions and Social Protest 1036
53.7 The Conservative Reaction 1037
53.8 The Folk Music Revival and The Commercialization of Folk Music... 1038
53.9 Conclusion 1040
References 1041
About the Authors 1043
Detailed Contents 1057
Subject Index 1079