

# Contents

0.1	Acknowledgements . . . . .	1
0.2	Preface . . . . .	3
0.3	Overview . . . . .	4
0.4	Symbols, Abbreviations and Transliteration . . . . .	6
<b>1</b>	<b>INTRODUCTION</b>	<b>9</b>
1.1	Subject Context . . . . .	9
1.2	Throat Singing (ThS) . . . . .	10
1.3	Overtone Singing (OtS) . . . . .	15
1.4	Theoretical Context Of Voice Description . . . . .	16
1.4.1	Perspectives, Layers and Definitions . . . . .	16
1.4.2	Principles of Phonation . . . . .	19
1.4.3	Voice Production – Source and Vocal Tract . . . . .	22
1.4.4	Voice Quality (VQ) . . . . .	23
1.5	Research Goals . . . . .	26
<b>2</b>	<b>SUBJECT</b>	<b>28</b>
2.1	Physiological & Acoustical Correlates of ThS Phonatory Qualities	28
2.1.1	Styles in South-Siberian Throat Singing – Ethnomusico- logical vs. Phonetic Perspective . . . . .	28
2.1.2	Physiological Phonetics of Throat Singing . . . . .	37
2.1.3	Voice Sources in Throat Singing . . . . .	38
2.1.4	Vocal Tract in Throat Singing . . . . .	38
2.2	Specific Anatomy of Certain Laryngeal Structures . . . . .	40

2.2.1	Basic Functional Anatomy of the Larynx . . . . .	40
2.2.2	Ventricular Fold and Ventricular Voice . . . . .	41
2.2.3	Aryepiglottic Fold ( <i>plica aryepiglottica</i> ) . . . . .	45
2.2.4	Aryepiglottic Sphincter (AES) . . . . .	46
2.3	Physical Examination of the Lower Vocal Tract in Throat Singing	48
2.3.1	Preliminary Laryngoscopic Examination of Throat Singing	48
2.3.2	Additional Recordings of Fibre Endoscopic Examination of Throat Singing . . . . .	56
2.4	Vocal Tract Shape Investigations – Articulation of “Reinforced Harmonics” in Throat Singing . . . . .	60
2.4.1	Observable Techniques or Methods of “Overtone Artic- ulation” . . . . .	60
2.4.2	Phonation Modes and Articulation Types in Throat Singing	62
2.4.3	Physical Observations on Singers . . . . .	72
2.4.4	Investigations using X-ray Videofluoroscopy . . . . .	72
2.4.5	Investigations using Ultrasound . . . . .	75
2.4.6	MRI Investigation . . . . .	75
2.5	Discussion of VPTs and Laryngeal Settings in Throat Singing . . .	76
2.5.1	Posterior-Anterior Compression, Supraglottal Constriction	76
2.5.2	Ventricular Fold Mechanism (VTF) – Medial Compres- sion of Supraglottal Constriction . . . . .	80
2.5.3	Double Source Phonation or Diplophonic Phonation . . .	81
2.5.4	Discussion of Vocal Tract Articulation . . . . .	85
2.6	HYPOTHESES & Expectations . . . . .	87
<b>3</b>	<b>METHOD – Physioacoustical Analysis of Voice Production in ThS</b>	<b>90</b>
3.1	Preliminary Considerations – Why do we need field data of ThS?	90
3.2	Specific Non-Invasive Methodology for Voice Investigation in Field Work . . . . .	91
3.2.1	Field Work within Voice Research . . . . .	91
3.2.2	Field Conditions in Southern Siberia . . . . .	92
3.2.3	Invasivity, Manageability, and Costs . . . . .	93

3.2.4	3-Channel-Recording of Voice, EGG, and Subglottal Pressure (Inverse Filtering) . . . . .	94
3.2.5	Subject Recruitment . . . . .	97
3.2.6	Subject Tasks and Raw Data Corpus Description . . . . .	98
3.3	Voice (Source) Analysis Design . . . . .	99
3.3.1	Preparation and Data Pre-Analysis . . . . .	99
3.3.2	Physio-Acoustic Analysis Methods . . . . .	101
<b>4</b>	<b>RESULTS</b>	<b>122</b>
4.1	Analysis and Findings in the Voice Signal (Vx) . . . . .	122
4.1.1	Vx-signal Corpus Description . . . . .	122
4.1.2	Vx Waveform Shapes and Patterns . . . . .	125
4.1.3	Vx Waveform Perturbations . . . . .	130
4.1.4	Formants, Bandwidths and Reinforced Harmonics . . . . .	143
4.1.5	Glottal Characteristics in the spectra (H1-H2, H1-A1, H1-A3 etc.) . . . . .	150
4.1.6	Average Spectral Characteristics . . . . .	153
4.1.7	Findings in Inverse Filtering Curves . . . . .	159
4.2	Analysis and Findings for Lx . . . . .	163
4.2.1	Sub-Corpus Description . . . . .	163
4.2.2	Findings in EGG and DEGG Wave Shapes (incl. Gx) . . . . .	163
4.2.3	Periods Obtained by Lx Measurement . . . . .	171
4.2.4	Jitter of the Lx Signal . . . . .	173
4.2.5	Shimmer of the Lx Signal . . . . .	174
4.2.6	EGG Quotients – Analysis and Findings . . . . .	179
4.3	Analysis and Findings for the Subglottal Pressure Wave Signal (Sx) . . . . .	183
4.3.1	Sub-Corpus Description . . . . .	183
4.3.2	Coordination of Vx, Lx and Sx . . . . .	183
4.3.3	Sx vs. Vx Waveform Comparison . . . . .	186
4.3.4	Spectral Analysis of Sx . . . . .	186
4.4	Additional Observations . . . . .	191
4.4.1	Air Flow in Different VPT . . . . .	191
4.4.2	Aryepiglottic Sphincter Constriction (MV → AESV) in Lx . . . . .	192

4.4.3	Variations in <i>kargyraa</i> (VTF-V, AEF-VF, etc.) . . . . .	194
4.5	DISCUSSION . . . . .	199
4.5.1	Interrelations and Correlations Between Measures . . . . .	199
4.5.2	Possible Voice Production Types . . . . .	200
4.5.3	Similarities to Other Pathological and Non-pathological Voice Patterns . . . . .	201
<b>5</b>	<b>SUMMARY</b>	<b>204</b>
5.1	Macrostructure and Microstructure of ThS . . . . .	204
5.2	Are Throat Singers High-Risk Vocal Performers? . . . . .	207
5.3	Perspectives . . . . .	208
<b>A</b>	<b>TABLES, DIAGRAMS &amp; SCRIPTS</b>	<b>210</b>
A.1	Tables . . . . .	210
A.1.1	Descriptive Statistics . . . . .	210
A.1.2	Normal Distribution Tests . . . . .	214
A.1.3	Nonparametric Rank Test . . . . .	221
A.1.4	Tables of Correlation Analysis . . . . .	229
A.2	Diagrams and Plots . . . . .	236
A.2.1	Descriptive Plots and Diagrams . . . . .	236
A.2.2	Spectra and Spectrograms . . . . .	241
A.2.3	Waveform and Waterfall Plots . . . . .	250
A.3	Scripts . . . . .	262
A.3.1	Script 1: Formants, Bandwidths, Harmonics . . . . .	262
A.3.2	Script 2: Obtaining Jitter, Shimmer, HNR, NHR, etc. . . . .	267
A.3.3	Script 3: Vx, Lx, Inverse Filtering of Vx, EGG-Quotients . . . . .	270
A.3.4	Script 4: Cascading Waveforms . . . . .	279
<b>B</b>	<b>REFERENCES</b>	<b>281</b>
B.1	Glossary . . . . .	281
B.2	Analysed Recordings . . . . .	283
B.2.1	Audio-CDs . . . . .	283
B.2.2	Broadcasts [B] & Documentaries[F] . . . . .	286

B.2.3	Field Recordings [FR] and Archive Material [AR] . . . . .	287
B.3	Subjects . . . . .	287
B.4	Bibliography . . . . .	289