

Unequal Temperaments

Theory, History and Practice

SCALES, TUNING AND INTONATION IN MUSICAL PERFORMANCE

3rd revised edition



Claudio Di Veroli

Unequal Temperaments and their Role in the Performance of Early Music,
Buenos Aires, Argentina

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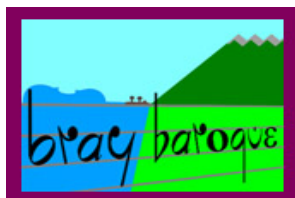
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Bray Baroque, Bray, Co. Wicklow, Rep. Ireland

To

Hubert Bédard (1933-1989),

Prof. Sir David R. Cox

and Debora, my mother

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Closing recital of the 2000 season at the Baroque Organ in the Cathedral, Buenos Aires, Argentina.

Born in Buenos Aires (Argentina) into an Italian family, **Claudio Di Veroli** studied the piano, recorder, clarinet, harmony and interpretation of early music under Ernesto Epstein, Erwin Leuchter, Ljerkó Spiller and other renowned musicians. Still in his teens he worked as a harpsichord tuner: as a performer he would later win several Argentine national musical competitions and play extensively in public recitals. With a degree in Mathematics, he moved to England where—supervised by Prof. David R. Cox—he pursued research in Mathematical Statistics at Imperial College, London. He simultaneously continued his musical training, studying the harpsichord under Colin Tilney in London and Hubert Bédard in Paris. He was granted access and practised extensively on the antique keyboards in the Fenton House London and the Paris Conservatoire's *Musée Instrumental*.

Having obtained his PhD, Di Veroli went back to Buenos Aires to work as a consultant in information systems and management, while always devoting considerable time and effort to music. He introduced in Argentina the harpsichords based on early models, building a French double Hubbard kit, later described in a leading newspaper as the best instrument of its kind in South America. Through decades of musical activity in Argentina, he pioneered the performance of Baroque music based on ancient instruments and practices.

Di Veroli has carried out extensive research in early musical instruments and performance. His writings have been endorsed by leading musicians such as Gustav Leonhardt, Igor Kipnis and John Barnes. They include four treatises that have received favourable reviews—*Unequal Temperaments and their role in the performance of early music* (1978), *Baroque Keyboard Fingering: A Method* (1983, 2008, 2012), *Unequal Temperaments: Theory, History and Practice* (2009, 2013), *Playing the Baroque Harpsichord: essays on the instrument, interpretation and performance* (2010)—and the recent edition of *Baroque Keyboard Masterpieces Fingered with Baroque Technique* (2011). He is also the author of several published papers, most recently in *Harpsichord & fortepiano* (UK).

As a soloist—mostly on the harpsichord but also on the organ—Di Veroli has performed extensively in concert halls, churches, radio and TV, both solo and with ensembles, with very favourable reviews in important newspapers. He has been Professor of Harpsichord and examiner of the Organ course at the *Conservatorio Nacional* in Buenos Aires. In the Bach-year 1985 he premiered the performance of J.S. Bach's harpsichord concertos using his own reconstruction of Bach's fingering technique, as described in his above-mentioned fingering method. Recent teaching practices include masterclasses in Argentina, Uruguay, Italy and Ireland.

Claudio Di Veroli is fluent in English, Spanish and Italian: he also reads and speaks French. He and his wife Betty relocated to Ireland in 2001: they live in Bray, a seaside resort located in County Wicklow, just south of Dublin.

CONTENTS 5

INTRODUCTION 11

PART ONE – DESCRIPTION, ANALYSIS, HISTORY

CHAPTER 1. MUSICAL INTERVALS

1.1 SOUND, HARMONICS AND SINE WAVES	16
1.2 BEATS, CONSONANCE AND DISSONANCE	17
1.3 HISTORICAL PERSPECTIVE OF BASIC ACOUSTICS	18
1.4 THE UNISON AND THE OCTAVE	20
1.5 THE FIFTH AND THE MAJOR THIRD	21
1.6 GENERAL LAWS ON CONSONANCE AND BEAT RATES	23
1.7 RATIOS AND BEATS OF CONSONANT INTERVALS	24
1.8 COMPLEMENTARY INTERVALS	25
1.9 THE TRIADS	26
1.10 ORNAMENTAL BEATS	27

CHAPTER 2. PYTHAGOREAN GENERATION OF THE MUSICAL SCALE

2.1 THE CIRCLE OF FIFTHS	28
2.2 THE KEYBOARD IN PYTHAGOREAN INTONATION	30
2.3 HISTORICAL PERSISTENCE OF PYTHAGOREAN INTERVALS	32
2.4 THE MONOCHORD	32

CHAPTER 3. EQUAL TEMPERAMENT–THE CENT–EVALUATION METHOD

3.1 INTRODUCTION	35
3.2 EQUAL TEMPERAMENT	36
3.3 THE CENT	37
3.4 CENTS OF PURE INTERVALS	38
3.5 ANALYSIS OF DEVIATIONS USING THE CENT	39
3.6 EVALUATION OF EQUAL TEMPERAMENT	41
3.7 EVALUATION METHOD FOR UNEQUAL TEMPERAMENTS	43
3.8 EVALUATION OF PYTHAGOREAN INTONATION	44
3.9 HARMONIC WASTE OF THE FIFTHS	46
3.10 HARMONIC WASTE OF THE MAJOR THIRDS	47

CHAPTER 4. JUST INTONATIONS

4.1 COMMAS, DIESIS, SCHISMA AND FORMULAE	48
4.2 JUST INTONATIONS	51
4.3 PYTHAGOREAN-JUST INTONATION	52
4.4 STANDARD JUST INTONATION OR NATURAL SCALE	55
4.5 JUST INTONATION AND VARIABLE INTONATION	59

CHAPTER 5. MEANTONE TEMPERAMENTS

5.1 GENESIS OF MEANTONE TEMPERAMENT	60
5.2 THE MEAN TONE	62
5.3 STANDARD (1/4 S.c.) MEANTONE TEMPERAMENT	63
5.4 SHARPS, FLATS AND THE SPIRAL OF FIFTHS	66
5.5 EXTENDED (2/7 S.c.) MEANTONE TEMPERAMENT	70
5.6 MINOR-THIRDS (1/3 S.c.) MEANTONE TEMPERAMENT	72
5.7 HOMOGENEOUS (1/5 S.c.) MEANTONE TEMPERAMENT	74
5.8 ATTENUATED (1/6 S.c.) MEANTONE TEMPERAMENT	76
5.9 ATTENUATING MEANTONE DOES NOT TAME THE WOLVES	79

CHAPTER 6. COMPARISON OF JUST AND REGULAR SYSTEMS

6.1 CLASSIFICATION OF REGULAR AND JUST SYSTEMS	80
6.2 DEVIATIONS IN REGULAR TEMPERAMENTS	81
6.3 A GENERAL COMPARISON OF THE FOUR CLASSICAL SYSTEMS	84
6.4 SCALES AND ENHARMONY	85
6.4.1 MELODIC IMPLICATIONS OF TEMPERAMENT	85
6.4.2 GENERATION OF THE SPIRAL OF FIFTHS	85
6.4.3 DIATONIC AND CHROMATIC TONES AND SEMITONES	85
6.4.4 PYTHAGOREAN INTONATION SCALE	85
6.4.5 STANDARD MEANTONE SCALE	86
6.4.6 NINE COMMAS IN A TONE	87
6.4.7 VARIANTS OF MEANTONE	87
6.4.8 STANDARD JUST SCALE	88
6.4.9 COMPARISON OF SCALES AND TONES	88
6.5 LISTENING TO MEANTONE IN AN EQUALLY-TEMPERED WORLD	89

CHAPTER 7. LUTE TEMPERAMENTS

7.1 FRETTED INSTRUMENTS AND TEMPERAMENT	90
7.2 SEMI-FRETTING	92
7.3 SEMI-PYTHAGOREAN TEMPERAMENT	92
7.4 SEMI-JUST TEMPERAMENT	94
7.5 SEMI-MEANTONE TEMPERAMENT	96
7.6 FRETTING IN MEANTONE TEMPERAMENTS	97
7.7 A GENERAL VIEW OF UNEQUAL FRETTINGS	99

CHAPTER 8. CIRCULAR FRENCH TEMPERAMENTS

8.1 CIRCULAR TEMPERAMENTS	101
8.2 EARLY FRENCH TEMPERAMENT	103
8.3 STANDARD (1/4 S.c.) FRENCH TEMPERAMENT	108
8.4 HOMOGENEOUS (1/5 S.c.) FRENCH TEMPERAMENT	112
8.5 SMOOTH TEMPERAMENTS — COMPARISON	115

CHAPTER 9. CIRCULAR “GOOD” TEMPERAMENTS

9.1 CLASSIFICATION OF “COMMA-SPLITTERS”	116
9.2 SCHLICK’S TEMPERAMENT	118
9.3 WERCKMEISTER III TEMPERAMENT	120
9.4 KELLNER’S BACH TEMPERAMENT	122
9.5 VALLOTTI/YOUNG TEMPERAMENT	124
9.6 BARNES’S BACH TEMPERAMENT	127
9.6a NEIDHARDT’S VILLAGE, TOWN AND CITY	130
9.7 THE SEARCH FOR BACH’S TEMPERAMENT	134
WERCKMEISTER	134
VALLOTTI	134
NEIDHARDT	134
MARPURG AND KIRNBERGER (AND KELLETAT)	135
KELLNER	136
BARNES	136
LEHMAN	137
LINDLEY	138
MYSTICISM	139
RANKING AND CONCLUSION ON EXISTING PROPOSALS	139
FULL 1/6 P.C. SEARCH	141
FURTHER 1/12 P.C. SEARCH – WTC BEST	141
HOW UNEQUAL WAS BACH?	143
9.8 CONCLUSIONS ON GOOD TEMPERAMENTS	144
9.9 VICTORIAN TEMPERAMENTS	145

9.10 APPROXIMATING EQUAL TEMPERAMENT	146
9.10.1 TEMPERING MOST FIFTHS	146
9.10.2 TEMPERING ALL THE FIFTHS	147
9.10.3 IMPROVEMENTS AND CHECKS	148
9.10.4 COUNTING BEAT RATES	148
9.10.5 IMPROVED BEAT RATE TABLES AND CHECKS	149
9.10.6 LOW-PRECISION ELECTRONIC DEVICES	149
9.10.7 HIGH-PRECISION ELECTRONIC DEVICES	149
9.11 ALMOST-EQUAL TEMPERAMENT	150

CHAPTER 10. FINAL COMPARATIVE EVALUATIONS

10.1 A GENERAL COMPARISON OF CIRCULAR TEMPERAMENTS	153
10.2 THE SCALES IN CIRCULAR TEMPERAMENTS	155
10.3 COMPARISON OF OFFSETS	156
10.4 A GENERAL CLASSIFICATION OF TEMPERAMENTS	157
10.5 THE EVOLUTION OF TEMPERAMENT	158

CHAPTER 11. TEMPERAMENT AND PERFORMANCE - A HISTORICAL REVIEW

11.1 MODERN RESEARCH AND PERFORMANCE	159
11.2 PLAINCHANT AND EARLY POLYPHONY	160
11.3 GOTHIC, A PYTHAGOREAN ERA	161
11.4 EARLY RENAISSANCE, A TRANSITIONAL PERIOD	162
11.5 HIGH RENAISSANCE, THE HEYDAY OF THE MEANTONE SYSTEM	163
11.6 SELECTING VARIANTS OF MEANTONE TEMPERAMENT	166
11.7 RENAISSANCE TEMPERAMENTS AND FRETTED INSTRUMENTS	167
11.8 BAROQUE IN FRANCE AND ENGLAND	169
BAROQUE FRANCE	169
BAROQUE ENGLAND	172
11.9 EARLY BAROQUE IN OTHER EUROPEAN COUNTRIES	174
EARLY BAROQUE IN EUROPE	174
TRANSPOSITION AND HARPSICHORDS	175
11.10 HIGH BAROQUE IN OTHER EUROPEAN COUNTRIES	176
PERSISTENCE, EVOLUTION AND DECLINE OF MEANTONE	176
HIGH BAROQUE AND "GOOD" TEMPERAMENTS	177
TEMPERAMENT, ENSEMBLE TUNING AND STRING INSTRUMENTS	178
WIND INSTRUMENTS AND PITCHES	178
PITCH, TRANSPOSITION AND KEYBOARD TEMPERAMENT	179
COMPARISON OF FRENCH AND GOOD TEMPERAMENTS	179
11.11 CLASSICAL AND EARLY ROMANTIC TUNING	180
PERSISTENCE OF UNEQUAL TEMPERAMENTS	180
THE IRRESISTIBLE ADVANCE OF EQUAL TEMPERAMENT	181
THE RATIONALE FOR EQUAL TEMPERAMENT	183
THE FATE OF FRETTED STRING INSTRUMENTS	184
11.12 LATE ROMANTIC AND MODERN TIMES	185
MECHANISED EQUALLY-TEMPERED WIND INSTRUMENTS	185
EQUALLY-TEMPERED MECHANISED WOODWINDS	185
EQUALLY-TEMPERED VALVED BRASS	186
PYTHAGOREAN STRINGS AND WINDS	186
EQUAL TEMPERAMENT IMPROVEMENTS IN TUNING ACCURACY	186
LATE-ROMANTIC UNEQUAL ATTEMPTS	187
MODERN UNEQUAL TEMPERAMENTS	188

PART TWO – TUNING AND FRETTING INSTRUCTIONS

CHAPTER 12. SETTING THE TEMPERAMENT OF A KEYBOARD INSTRUMENT

12.1 ELECTRONIC TUNING DEVICES	190
12.2 TUNING BY EAR	191
12.3 HEARING THE SLOWEST BEATS	191
12.4 TUNING INTERVALS BY EAR	192
12.5 MEASURING BEAT RATES	193
12.6 BEAT RATES AND TUNING PITCH	194
12.7 COMPARISON OF BEAT RATES AS HISTORICAL METHOD	195
12.8 COMPARISON OF BEAT RATES IN MODERN SCHEMES	195
12.9 OCTAVE TESTS	196
12.10 THIRTY(30) HINTS AND TRICKS FOR HARPSICHORD TUNING	197
12.11 CHANGING THE TEMPERAMENT OF A KEYBOARD INSTRUMENT	203
12.12 TRANSPOSING KEYBOARDS AND TEMPERAMENT	204
12.13 MIDI AND PC PLAYING IN UNEQUAL TEMPERAMENTS	205
12.14 SOME REMARKS ON ORGAN TUNING AND STOPS	207
12.15 TUNING FOR KEYBOARD DUETS OR TRIOS	208

CHAPTER 13. TEMPERAMENT SCHEMES FOR KEYBOARD INSTRUMENTS

13.1 SYMBOLS FOR THE TEMPERAMENT SCHEMES	212
13.2 THE PURE INTONATIONS	213
13.3 STANDARD MEANTONE TEMPERAMENT	216
13.4 EXTENDED MEANTONE TEMPERAMENT	220
13.5 MINOR-THIRDS MEANTONE TEMPERAMENT	223
13.6 HOMOGENEOUS MEANTONE TEMPERAMENT	225
13.7 ATTENUATED MEANTONE TEMPERAMENT	229
13.8 SEMI TEMPERAMENTS	233
13.9 MERSENNE-CHAUMONT TEMPERAMENT	234
13.10 EARLY FRENCH (COUPERIN) TEMPERAMENT	237
13.11 STANDARD FRENCH (ROUSSEAU) TEMPERAMENT	240
13.12 HOMOGENEOUS FRENCH TEMPERAMENT	244
13.13 SCHLICK'S TEMPERAMENT	247
13.14 WERCKMEISTER'S III TEMPERAMENT	249
13.15 KELLNER'S BACH TEMPERAMENT	251
13.16 VALLOTTI'S TEMPERAMENT	252
13.17 VALLOTTI/YOUNG TEMPERAMENT	255
13.18 BARNES'S BACH TEMPERAMENT	258
13.19 BACH WTC BEST+ TEMPERAMENT	261
13.19a NEIDHARDT'S 5TH CIRCLE #8 "BIG CITY"	262
13.19b NEIDHARDT'S 3RD CIRCLE #5	264
13.20 BROADWOOD'S BEST TEMPERAMENT	266
13.21 ALMOST-EQUAL TEMPERAMENT	267
13.22 EQUAL TEMPERAMENT	270
13.23 DO-IT-YOURSELF TEMPERAMENT SCHEMES	273

CHAPTER 14. TEMPERAMENT SCHEMES FOR FRETTED CLAVICHORDS

14.1 TUNING A FRETTED CLAVICHORD	274
14.2 CHANGING THE TEMPERAMENT	275
14.3 TEMPERAMENT AND THE FRETTING PATTERN	275
14.4 PURE INTONATIONS	277
14.5 MEANTONE TEMPERAMENTS	278
14.6 FRENCH CIRCULAR TEMPERAMENTS	280
14.7 GOOD TEMPERAMENTS	281
14.8 EXTENDING THE TUNING	284

CHAPTER 15. FRETTING INSTRUCTIONS

15.1 STANDARD LUTE AND VIOL TUNINGS	285
15.2 GEOMETRICAL FRETTING PROCEDURES	286
15.3 FRETTING THE IRREGULAR LUTE TEMPERAMENTS	292
15.4 EMPIRICAL FRETTING METHODS	294
15.5 PYTHAGOREAN FRETTING	296
15.6 PYTHAGOREAN-JUST FRETTING	300
15.7 STANDARD-JUST FRETTING	305
15.8 MEANTONE FRETTING	307
15.9 ENHARMONIC MEANTONE FRETTING	321
15.10 EARLY FRENCH FRETTING	322
15.11 CIRCULAR FRETTINGS	324
15.12 CITTERNs	329
15.13 EQUAL TEMPERAMENT AND THE RULE OF 18	330

CHAPTER 16. INTONATION FOR VIOLINS AND VOICES 331

16.1 JUST INTONATION FINGERING	331
16.2 MEANTONE FINGERING	332
16.3 EARLY FRENCH FINGERING	336
16.4 STANDARD FRENCH FINGERING	337
16.5 FINGERING IN A GOOD TEMPERAMENT	338
16.6 PYTHAGOREAN FINGERING	340
16.7 SLIDE TRUMPETS AND TROMBONES	341
16.8 VOICE INTONATION	341
16.9 VARIABLE INTONATION	342

CHAPTER 17. INTONATION FOR WOODWINDS

17.1 NO UNEQUAL TEMPERAMENTS FOR MODERN WOODWINDS	347
17.2 UNEQUALLY TEMPERED EARLY WOODWINDS	348
17.3 RECORDER AND UNEQUAL TEMPERAMENTS	349
17.4 BAROQUE TRANSVERSE FLUTE AND UNEQUAL TEMPERAMENTS	350
17.5 BAROQUE OBOE AND UNEQUAL TEMPERAMENTS	351

CHAPTER 18. INTONATION FOR BRASS WIND INSTRUMENTS

18.1 MEANTONE FOR VALVED BRASS	353
18.2 NATURAL TRUMPET AND HORN	357
18.3 THE NAT IN D	361
18.4 THE NAT IN C	363
18.5 THE NAT IN F	365
18.6 THE NAT IN Eb	367
18.7 NATS IN G AND Bb	369
18.8 CHORTON AND KAMMERTON	369
18.9 HAND HORNS AND TRUMPETS WITH SLIDES	370

PART THREE – COMPLEMENTARY TOPICS

CHAPTER 19. MULTIPLE DIVISIONS

19.1 ADDITIONAL NOTES IN JUST INTONATION	373
19.2 SALINAS'S 24-NOTE SYSTEM	374
19.3 BAN'S 18- NOTE KEYBOARD	375
19.4 HELMHOLTZ'S 24-NOTE SYSTEM	377
19.5 FROM MULTIPLE-JUST TO MULTIPLE-REGULAR SYSTEMS	380
19.6 19-NOTE KEYBOARDS AND DIVISION	380
19.7 VICENTINO'S 31-DIVISION	383
19.8 QUARTER-TONE 24-DIVISION	386
19.9 SYSTEMATIC EXPLORATION OF ETS	387
19.10 ETS AS LOGARITHMIC INTERVAL UNITS	390

CHAPTER 20. FURTHER INTERESTING TOPICS

20.1 TRITONES AND MINOR SEVENTHS	394
20.2 CIRCLE OF INTERVALS OTHER THAN FIFTHS/FOURTHS	396
20.3 NINE COMMAS IN A TONE	397
20.4 THE 13TH STRING IN FLEMISH TRANSPOSING HARPSICHORDS	399
20.5 COUNTING THE NUMBER OF POSSIBLE TEMPERAMENTS	401
20.6 ORNAMENTAL BEATS IN MEANTONE VARIANTS	402
20.7 FULL CATALOGUE OF INTERVALS	405
20.8 FULL CATALOGUE OF FIFTHS	406
20.9 FULL CATALOGUE OF MAJOR THIRDS	407

CHAPTER 21. ANALYSIS OF SOURCES ON TEMPERAMENT 408

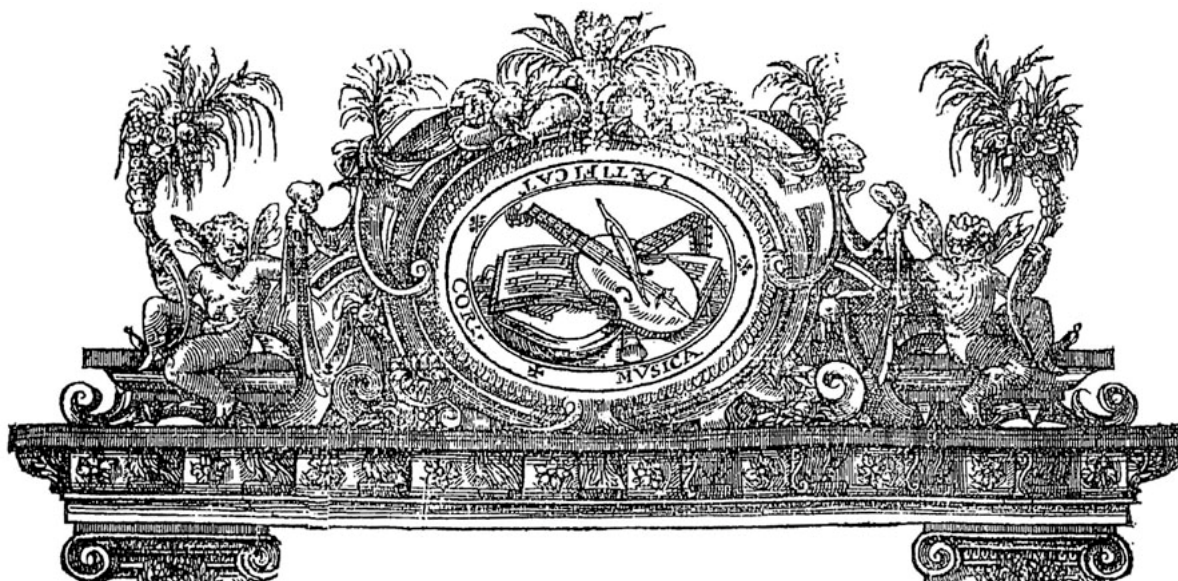
21.1 ARON'S TEMPERAMENT INSTRUCTIONS OF 1523	409
21.2 FRANÇOIS COUPERIN'S ORGAN TEMPERAMENT	412
21.3 A REAPPRAISAL OF THE "TEMPÉRAMENT ORDINAIRE"	418
21.4 SCHLICK'S TEMPERAMENT REVISITED	430
21.5 WERCKMEISTER'S TEMPERAMENTS	434
21.6 NEIDHARDT'S TEMPERAMENTS	438
21.7 A REMARK ON MARPURG'S TEMPERAMENTS	441
21.8 BACH'S TEMPERAMENT: 1/6 P.C. SEARCH	442
21.9 BACH'S TEMPERAMENT: 1/12 P.C. SEARCH	444
21.10 BACH'S TEMPERAMENT: AMOUNT OF INEQUALITY	446
21.11 THE PURPORTED HANDEL'S TEMPERAMENT	447
21.12 ALMOST-EQUAL TEMPERAMENT: MATHEMATICAL DEDUCTION	448
21.13 BARBOUR'S TEMPERAMENT	450
21.14 THE DELUSION OF VIOLIN-FRIENDLY TEMPERAMENT	451
21.15 THE TEMPERAMENT DESCRIBED IN SCORZI'S SPINET	452
21.16 EQUAL TEMPERAMENT BY PURE FIFTHS	453
21.17 THE VALLOTTI SAGA	454
21.18 THE EQUAL-BEATING TEMPERAMENT	457

CHAPTER 22. APPENDICES 458

APPENDIX 1: ON CONSONANCE, DISSONANCE AND SCIENCE	459
APPENDIX 2: FIFTH HARMONIC WASTE IN EARLY FRENCH TEMPERAMENTS	460
APPENDIX 3: FIFTH HARMONIC WASTE IN STANDARD FRENCH TEMPERAMENT	461
APPENDIX 4: CONFUSION BETWEEN SEMI-MEANTONE AND ORDINAIRE	462
APPENDIX 5: MATHEMATICAL COINCIDENCES IN MUSIC	464
APPENDIX 6: TEMPERAMENTS AND HARPSICHORD/CLAVICHORD STRINGING	467
APPENDIX 7: DECIMAL PLACES REQUIRED IN CENTS	473
APPENDIX 8: PHOTOGRAPH SOURCES	474

SOUND EXAMPLES 475

LITERATURE CITED 477



Upper part of the front page from Robert Dowland's *Varietie of Lute-lessons*, 1610.

"twelve perfectly equal semitones ... this practice does not seem up to nowadays to have pleased Musicians ... they cannot be persuaded to depart with the energetic variety they find among the different affections of the Tones caused by the established [unequal] Temperament. ...

JEAN JACQUES ROUSSEAU, 1765

INTRODUCTION

[This new Introduction replaces the Prologue and Revival sections of previous editions.]

In Western music, "intonation" or "temperament" is the way the octave is subdivided into twelve or more similar steps, producing the familiar twelve semitones. This is needed, prior to performance, in all the musical instruments with fixed notes: keyboards, woodwinds and fretted strings. Even when initially set by the maker—as in organs and wind instruments—the temperament can be modified afterwards by either makers or tuners, and also by the performers while playing non-keyboard instruments.

Subdividing the octave yields the notes that allows us to produce melodies (when played in sequence) and intervals (when played simultaneously), which are the foundation of Western music. Unfortunately, natural and mathematical laws show that the most important musical intervals are mutually incompatible. If we try to tune perfect or "pure" all the octaves and fifths, we find that at least one fifth must be left noticeably out-of-tune or "impure": also, most major thirds are very noticeably impure. An even greater imbalance occurs if we try—in vain—to tune pure all the octaves and major thirds. Hence the necessity of a compromise or "temperament", a term that originally meant the tuning of impure intervals.

Temperament, like the other components of musical performance, has undergone significant changes in history. Our modern Equal Temperament was well known already in the Renaissance era, but it only became common practice in the second half of the 18th century. For most earlier music—composed in the Medieval, Renaissance and Baroque eras—musicians found issue with the uniform dissonance of equally-tempered intervals. They preferred various kinds of *unequal temperaments*, in which the "total dissonance" was allocated in different amounts to each specific interval. For instance, some major thirds could be very consonant or even absolute pure, while others—inevitably—would be quite dissonant or even unplayable. The final result was that music sounded better in tune, because the most frequently employed intervals and chords were significantly more consonant than the others. Music played following historical temperaments acquires an entirely new sound and meaning.

With the modern revival of ancient practices and instruments, the interest in historical temperaments arose. The reasons were not only musical but also practical: early instrument manufacture and playing techniques were tailored for playing in unequal temperaments.

Helmholtz observed that differences in temperament are clearly heard even by unmusical ears (Helmholtz 1862 p. 320). An early modern account on meantone temperament was written by **S. A. Hurren** and included in **William Braid White's** classical work on piano tuning (White 1946 App. 4). Modern work on historical temperaments began with **J. Murray Barbour**, who collected his findings in an often-quoted book (Barbour 1951). Also very widely read were two treatises by **Owen Jorgensen** (Jorgensen 1977 and 1991).

Unfortunately, **Barbour** was for temperaments what Wanda Landowska was for harpsichords. As 20th century pioneers, they helped to revive the interest in important and forgotten matters, and also—inevitably—first identified some relevant details. Unfortunately, they were also very influential in the diffusion of many ideas that were shown to be unhistorical by later research. Barbour included in his book (1951) the descriptions of 178 temperaments, many of them gathered from historical sources hardly ever studied before. Nevertheless, many of his deductions were inaccurate, and he ignored some very important—available—sources. Barbour's analysis of each temperament was minimal, which is to be expected in a book that in A4 prints in just 138 pages. Actually, his goal was just to show the "historical evolution towards equal temperament", the latter being *a priori* considered the only one worth tuning in: his analysis of every temperament was mostly limited to concoct a single number representing how much it departs from Equal Temperament. More than half a century later, for today's scholars and performers, the contents of Barbour's book are mostly useless and often inaccurate and misleading.

Owen **Jorgensen** was very influential—especially in the USA—in spite of a review observing that "He knows how to write history ignoring historical data. ... he has probably not read any historical source ... he only mentions three ancient sources ... His knowledge of historical temperaments is entirely obtained from Barbour's book and therefore fully follows all of Barbour's limitations and errors. ... all sense of responsibility for the historical truth is missing" (Rasch 1980). As for Jorgensen's book of 1991, some of its main assertions have been shown to be in error (Sturm 2011).

Not surprisingly, until the 1980s the practice of the historical unequal temperaments was limited to a few performers. It was also—and to some extent still is—hampered by the inaccuracies of oral transmission, beliefs not supported by historical or scientific evidence, and the use of rules of thumb when precise knowledge and accurate methods are available. In order to put a historical temperament into practice, the modern musician needs (1) a structured account of its main features in musical performance, (2) information on its historical use and (3) a keyboard tuning method or advice for intonation in non-keyboard instruments. This information was hardly found in modern publications prior to 1980.

My personal journey to the temperaments world started in Paris in the late 1960s. Having met the late **Hubert Bédard**, then Director of the *Atelier de Restauration, Musée Instrumental, Paris Conservatoire*, I was introduced to each one of the antique harpsichords that Bédard and his team had lovingly restored and tuned with different unequal tunings. Bédard and Pierre Dumoulin were there to accompany visitors and kindly answer their questions. Bédard's work on temperaments was mostly intuitive, but he was a great musician and communicator: he will be remembered for his generous and inspiring influence on a whole generation of harpsichordists who—like myself—were lucky to be around Paris in the 1960s and 1970s.

Two decades later, the *Musée Instrumental* was transferred to the beautiful new *Musée de la Musique* in *La Villette*, north of Paris. This is surely better for the instruments' long-term preservation, but unfortunately the former fruitful, invaluable and intimate contact between students, scholars, musicians and instruments has been lost in the process. In a personal visit a few years ago I could not find anybody from the *Musée* to talk to: as for the instruments, they are aseptically isolated behind glass panels.

After I moved back to my hometown, Buenos Aires, I started my work on temperaments in 1975. After Barbour, the main additions to the literature had been a booklet on harpsichord tuning by **G.C. Klop** (Klop 1974) and a short but didactic article by **Mark Lindley** on Pythagorean, meantone and circular temperaments for the harpsichord (Lindley 1977). By then I was trying to put together a comprehensive account on temperaments for the tuning and performance of early instruments. I was lucky to have a background in science and also in the performance, tuning and repair of keyboards and woodwinds. Complex calculations were a serious issue at the time: there were no personal computers or spreadsheets, and I spent months developing and running FORTRAN programmes on a university computer.

At this point my work gained further momentum thanks to a gift from my late father, Angelo Di Veroli: by a lucky chance he found at an auction in Buenos Aires an original leather-bound copy of the original edition of Jean-Jacques Rousseau's "*Dictionnaire de Musique*", Geneva/Paris 1765. Featuring a crucially important description of the *tempérament ordinaire*, to which I eventually devoted some research, Rousseau's *Dictionnaire* still enjoys pride of place in my personal musical library.

When large audiences came to an audio-visual course on Musical Scales and Temperament, which I delivered at the *Goethe Institut* in Buenos Aires, I was urged in lieu to produce a full treatise, and by 1978 the book *Unequal Temperaments and their Role in the Performance of Early Music* was ready. Finding the right publisher proved difficult, however: eventually I had it "electrically typed", with hand-drawn figures, and printed by a local shop. After an advertisement published in *Early Music*, Vol.7 p. 550, hundreds of purchase orders followed, mostly from booksellers and libraries in the USA, UK, Sweden, Argentina, Spain and Japan.

In May 1980, Rudolf Rasch published—in Dutch—in *Stimulus*, the Ancient Music journal of the University of Utrecht, a detailed review of *Unequal Temperaments*. Rasch praised both the theoretical framework of the book and the emphasis in the historical relevance of each temperament for the present-day performance of music from different periods and styles.

Quite a few musicians wrote me kind letters with positive comments and the authorisation to make them public. Among them were the harpsichordist Igor Kipnis from the USA, the Argentinian conductor Sergio Siminovich, Hubert Bédard from Paris and John Barnes from Edinburgh. Bédard wrote: "The most useful text on the subject I have seen yet. ... This book ... seems to settle the matter at last." John Barnes found the book "A beautiful achievement ... Musicians will find that it answers questions that are not treated in any other text."

Eventually the book sold out. In 1985 I received a proposal from the Oxford University Press for a revised 2nd edition: unfortunately, for internal marketing reasons, they eventually shelved the project. There were no reprints or revised editions of the 1978 book.

In the following decades much new valuable work on ancient documents and temperaments was published by leading researchers in the field. I expected that one of them would sooner or later publish an updated reference treatise, but this never happened. Eventually, three decades having elapsed since the 1978 book, I started working on this new book, devoting to it most of 2007 and 2008.

The present book is not a revision but a new treatise written from scratch. It does include the contents of the 1978 book, but it also incorporates the results of new published research, including recent discussions by/with colleagues. As before, theoretical matters—musical and scientific—not directly related to musical practice are kept to a minimum. Conversely, the number of figures has been hugely increased, including colour pictures and charts employing state-of-the-art computer tools.

In the last few decades, unequal temperaments have undergone a separate parallel revival for specially-composed modern music. These interesting developments are found in new publications and are not covered in the present book, which deals with "classical Western" music only.

Needless to say, the present book is neither a complete account of modern research nor a catalogue trying to cover the universe of all the temperaments ever described. Such a thing would need many thousands of pages, and would be of scarce value to the modern musician, who can only handle a few temperaments. The MISSION STATEMENT for the present book is:

*"To draw from selected ancient writings and the wealth of modern research, and to explain everything the modern musician needs to know in order to understand and employ those **few** musical temperaments that gained **widespread acceptance** in times and places of significance in the history of Western music."*

Let me now describe some of the book's main features in its present 3rd edition.

- **TREATMENT OF EVERY TEMPERAMENT.** Most modern writings either quote and comment on ancient documents, or else explain complex mathematical derivations. Here instead we provide a simple and unified—yet exhaustive—mathematical formulation, a description of the temperament's main musical properties, and a history of its use in practice.
- **CHARTS, PHOTOS AND BOXES.** Figures make reading more enjoyable, explain concepts with graphical metaphors, and help to consolidate newly-acquired knowledge. In this edition many figures have been improved, and new photographs of ancient documents and instruments have been added. Colour in text boxes has now been standardised: **Curiosities** , **Useful comments** , **Figures** , **Dubious ideas** , **Maths, acoustics and caveats**.
- **SOUND EXAMPLES.** A companion set of 27 sound files has been produced: they can be freely downloaded from the webpage <http://temper.braybaroque.ie/spread.htm> . Each example is cited in the text where appropriate, and the full list is included at the end of the book before the final list of *Literature Cited*.
- **ORIGINAL TUNING DIRECTIONS.** These are written in the style found in early tuning instructions, and are meant to fully convey the feeling of ancient tuning practices.
- **TEMPERAMENTS AND MATHEMATICS.** In recent times a few writers have written extensive works about temperaments without using mathematics at all: supposedly this makes things easier to understand. Yet, even since the Middle Ages, writers knew that mathematics is needed to substantiate and explain the basics about intervals, scales and temperament. The reader is spared high-level maths such as calculus, continuous fractions or advanced statistics: only secondary school algebra and elementary statistics are used in this book.
- **HYPERLINKS.** They are no longer included in this edition: most of them failed to work in the final PDF file, a common issue of the conversion of large files. The links in the Table of Contents do work, however. As for the Internet, the reader can just copy any web address from the text and paste it into the address box of the web browser. The web addresses in this book have all been updated and are valid as per December 2012.
- **LANGUAGE.** The present book follows British English usage. In the 3rd edition the usage of some common terms has been improved. For example, "flat, flatter, to flatten" and "sharp, sharper, to sharpen" are now used for single notes only, while for intervals we use instead "narrow, narrower, to narrow" and "wide, wider, to widen".
- **SPREADSHEETS.** Years ago I made spreadsheets available online: they included scores of worksheets, one for every temperament. While this provided flexibility for individual temperaments, general improvements required endless repetitions, and inconsistency of presentation was inevitable after years of small changes. A new much simpler spreadsheet has now been produced. (<http://temper.braybaroque.ie/spread.htm>). For more details see the text box immediately before Section 13.1.

PART ONE of this book begins with a substantial introduction to the acoustics and simple modern mathematics of temperament. The most important historical temperaments are then covered, with a concise but systematic analysis of their acoustical and musical features. This part ends with a detailed **HISTORICAL SURVEY** intended to guide the performer in the selection of the temperament(s) to be used for his/her repertoire.

PART TWO consists of keyboard tuning and fretting instructions for several temperaments, followed by unequal-temperament directions for unfretted strings, voices, woodwinds and brass wind instruments, including variable intonation techniques. The different groups of instruments are covered in independent chapters, allowing the reader to employ only the chapters relevant to his/her specific musical interest.

PART THREE covers additional matters: multiple divisions of the octave, the analysis of some important historical sources, and some new relevant research.

LITERATURE CITED: the bibliographical references are given in full only in this list at the end of the book. No indexes are needed in a computer file, where searches are easy to perform.

The above arrangement should fulfil the goal of easy accessibility by readers with different interests: performers, tuners, makers, musicologists, students and amateurs.

Four years after the very successful 2nd edition of April 2009, some opportunities for improvement have been kindly reported by readers and colleagues. Even more significantly, through continuous revisions and studying recently-published research, the author found that quite a few topics benefited from an improved treatment. This has resulted in more than 30 additional pages for this new 3rd edition, hopefully the definitive one.

Readers of the 2nd ed. will find significant additions or enhancements in the following topics:

- Werckmeister III temperament
- Vallotti/Young temperament
- Neidhardt's temperaments
- The search for J.S. Bach's temperament
- Tuning for keyboard duets or trios
- Historical review of temperaments in performance
- History of Variable Intonation for winds and strings
- Historical trends within the French *tempérament ordinaire*
- Leigh-Silver's Equal-Beating temperament
- Relevance of temperament in the stringing list of the harpsichord and clavichord

There are also minor additions or improvements in the following topics:

- Schlick's temperament
- Historical genesis of meantone temperament
- Gallimard's logarithmic tunings
- Almost-Equal temperament
- Intonation for brass wind instruments
- Mathematical coincidences in music
- Literature Cited (44 new entries), and many others.

This book owes a lot to many persons, but mainly to:

- **Hubert Bédard** and **Pierre Dumoulin**, who introduced the author to the practice of tuning in unequal temperaments in Paris back in 1969-1971.
- **Sergio Siminovich** and **Carlos López Puccio**, remarkable musicians in Argentina who helped to improve the first draft of the original *Unequal Temperaments* book (1978).
- **David Bauguess**, master keyboard tuner in Colorado, USA, who offered many useful suggestions for the 1st edition of the present eBook (2008).
- **Fred Sturm**, concert pianist and piano technician in the faculty of the University of New Mexico, USA, who edited the text for the 2nd edition (2009).
- **John O'Hagan**, learned Irish musicophile and active collaborator of Bray Baroque, who edited the text for this 3rd edition.

Claudio Di Veroli, Bray, Ireland, April 2013.

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The list below includes all the publications consulted for—and cited in—this treatise, excluding musical scores. The reader wishing to check a full specialised list will find online the *Tuning & temperament bibliography* by Manuel Op de Could, Brian McLaren, Franck Jedrzejewski and Dominique Devie, with about 6,000 entries: <http://www.huygens-fokker.org/docs/bibliography.html> (acc. Dec. 2012), which, nevertheless, does not include all the works cited here.

Most of the ancient literature listed below is available in modern reprints, often also in English versions. Reprints are only mentioned when they are cited in the present book: the reader can otherwise find the information and availability on the Internet. The list is sorted first by author surname, then by year of publication, then by title.

Whenever a work (fully or partially or just an abstract or contents list) is freely available from the Internet, the web address—checked to be valid in Dec. 2012—has been included in blue colour: there is no hyperlink, but the webpage can be accessed in the Internet by simply copying it from here and pasting it into the web browser's Address box.

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