TUNING THE CLASSICAL GUITAR: A COMMENTARY AND GUIDE

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# Table of Contents

<table>
<thead>
<tr>
<th>Page</th>
<th>Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>iii</td>
<td>Declaration of Originality</td>
</tr>
<tr>
<td>iv</td>
<td>Acknowledgements</td>
</tr>
</tbody>
</table>

1 Introduction
   - Delineation of the Topic
   - Research Limits
   - Definition of Terms
   - Synopsis of Chapters

## PART A

9 CHAPTER 1: Temperaments and an Alternative Future for Guitar Tuning
   - Pure Intervals and Temperament
   - The Acceptance of Equal Temperament
   - Temperaments Explained
   - The Problem with Temperament
   - Mean-tone and Irregular Mean-tone Temperaments
   - Recovering the Sensitivity of the Western Ear
   - Application of Irregular Mean-tone Temperament to the Guitar

19 CHAPTER 2: Problems with the Existing Pedagogical Literature
   - Where is the Knowledge?
   - Unquestioned and Accepted Norms
   - Methodologies Examined
   - Solution: A Reliable Method for Tuning the Guitar to Equal Temperament
   - Tuning Habits to Avoid
   - Harmonics
   - Pure Intervals
   - Tuning Using Open and Fretted Notes
   - Compounding Tuning Methods
PART B

CHAPTER 3: Idiosyncratic Tendencies Affecting Tuning of the Guitar
   The ‘Problematic Third String’
   Fretting System Problems
   String Compensation: An Example of a Solution

CHAPTER 4: Scordature
   Drop D Tuning: An Example of a Common Scordatura
   The Challenges of Executing Scordature in Concert
   Properties of Polymers (Nylons)
   A Method for Coping with String ‘Creep’
   An Example of a Method for Tuning a Simple Scordatura: Drop D Tuning
   Summary of Method: Drop D Tuning
   Complex Scordature
   Re-tuning Scordature to Standard Tuning
   Complex Scordature: Programming and Practice
   The Use of the Capo

CHAPTER 5: Factors Affecting Tuning During Performance
   Left Hand Fretting Pressure
   Lateral String ‘Stretching’
   The Effects of Temperature on Tuning

CHAPTER 6: Conclusion

References
This is to certify that

(i) this dissertation comprises only my original work towards the Master of Performance, VCA Music, The University of Melbourne.

(ii) due acknowledgement has been made in the text to all other material used,

Signed

Anthony Robert Field
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INTRODUCTION

Delineating the Topic

The topic of this dissertation came to mind during a January 2008 recording session with the Melbourne Guitar Quartet of which I am a member. In the final days of recording it dawned on me that we had spent close to a quarter of the 40 hours allocated for the project on tuning. It was at this time that one of the members of the group uttered casually, between takes, “tuning ... now that would make a good thesis topic.” I suspect this remark was in response to the frustration at having spent so many hours tuning between takes. I also believe that it was an oblique reference to the mystery of guitar tuning, which the recording process so clearly highlights.

Prior to this moment of realisation, I had never considered tuning as a research topic. Was tuning not something everyone just knew how to do? To most guitarists it would not bear thinking about. However, the more I thought about the topic the more I realised how little I (and perhaps the guitar playing community as a whole) knew about the inner workings of guitar tuning and also how underrated it is in guitar playing and its pedagogy. How could something apparently so critical to successful musical communication be neglected in a guitarist’s education?

As a professional performer and tertiary lecturer of the classical guitar, I have observed the difficulties and complexities involved with tuning the guitar and a distinct lack in the instrument’s formal pedagogy to address it in detail. In my 15 years of formal practical classical guitar education at no time was tuning examined in any meaningful detail. How is it that in all my education as a musician and classical guitarist at no time were the problems and peculiarities associated with tuning the guitar highlighted? One could at least expect there to
be substantial discussion about the subject in classes at university. Surprisingly, I cannot recall any such occasions. What reasons are there for the omission, what are the implications for guitar performance, and how can the omission be rectified?

I do not wish to blame teachers, institutions or guitar schools for any deficiencies; I suggest, rather, that the problem is endemic in western musical culture as a whole, and can in some measure be attributed to the unquestioned implications caused by the evolution of equal temperament.

It is possible that the advent of fixed frets upon the modern instrument has caused a general disappearance of tuning knowledge in today’s guitar playing community (perhaps all except early music specialists) and this in turn has given rise to confusion in respect of the precise intricacies involved in tuning the guitar. Indeed why would one need to know about the frets? The assumption is that because frets are fixed, and as long as one tunes the strings accurately enough to E-A-D-G-B-D the guitar should be in tune? It is not that simple.

There are also fundamental practical and idiosyncratic tuning issues that need to be addressed and that require an adequate response from the guitarist. If a guitarist is unaware of these issues the consequences can be severe. For example, I have witnessed professional guitarists at the height of their career fall victim to the reactions of strings when they are radically shifted in pitch (tension) in order to perform using different scordature. Setting strings to different scordature is an extremely common practice for guitarists, and yet one witnesses players struggling with this practice in concert regularly. It seems that we, as guitarists, are compromising on this problem without pursuing solutions to it.
From my observations as a teacher and player, tuning the guitar requires a more detailed and thorough approach than it currently receives. This raises many questions, for instance, what physical phenomena occur in strings after having their tension suddenly altered (such as required by common classical guitar repertoire) and how can one expect a string to react in the readjustment process? Is the fretboard tempered? If so, how? What effect do frets have on string tension, if any? Indeed, if one is to learn the art of good tuning then one requires guidance in the subject matter relating to these and many more questions.

Having played pieces in ensemble and in solo settings involving various tuning difficulties, it is my experience that tuning the classical guitar requires skill and practice. It is surprising, then, that few specific resources are available on the subject. It is my theoretical position, after reviewing some of the principal literature that exists about tuning, that the body of knowledge diminishes with the advent of fixed frets on guitars (roughly between 1780-1850).¹

There are many theoreticians who devised methods for tuning fretted instruments before this time. For example Juan Bermudo’s Declaracion De Instrumentos Musicales (1555) outlines tuning schemes for seven different vihuelas (early guitars) and, “[r]efferences to altering the fret positions are found in the books of both [well known vihuelists] Milan and Valderrabano” (Griffiths 1997:172). On discussing variations of equal temperament for fretted instruments in the 16th century, James Barbour states:

> It might have been the Grammateus-Bermudo tuning — Pythagorean with mean semitones for the chromatic notes. It might have been the Ganassi–Reinhard mean semitones applied to just intonation,

¹ Evidence for fixed frets becoming standard on the guitar appears to be between these dates according to Savino.
or Artusi’s more subtle system of mean semitones in mean-tone temperament. Or the frets might have been placed according to Galilei’s 18:17 ratio, or (correctly) according to Salinas’ ratio of the 12\textsuperscript{th} root of 2 (1951:188).

The persons named by Barbour are some of the great theorists on tuning, and it can be assumed that serious players of fretted instruments were very aware of the tuning methods that were required for their repertoire.

The guitar was very popular through the 1600s to the late 1700s and did not possess fixed frets. One would assume that until the frets became fixed, players would have had to remain informed (at least in part) about the precise nature of tuning for their instruments. It appears that after the frets became fixed, knowledge and critical examination of tuning diminished and then eventually evaporated. It was common in the 1500s for composer-guitarists to publish tuning instructions with their music (for example, Milan and Valderrabano), however this practice ceased in publications after 1850. This fact is illustrated by Fernando Sor’s complete omission of tuning from his method published in approximately 1850. Sor’s method is thorough in every manner except tuning, so one can only assume that he no longer regarded it as important.

Tuning methods appear in publications after this time (for example, in the methods of Aaron Shearer and Pascual Roche), but only in the form of brief instructions which do not inform the student about why the frets are positioned where they are, the temperament in which they are set, or any other relevant tuning considerations. It must also be noted that it was not until 1917 that tuning to equal temperament became truly standardised, and not until the mid
1800s when it was considered by many to be the ideal tuning system. I argue that knowledge about systems of tuning diminished significantly after this time and almost completely evaporated after 1917.

Through the research undertaken for this dissertation, I have also begun to question the desirability of equal temperament itself. This has led me to examine the way the modern instrument’s construction limits the options available to it and to take a new outlook on tuning regarding the instrument’s future.

The research for this dissertation would be lacking if the discussion of tuning methods for the modern guitarist did not examine equal temperament in the broader context of western tuning systems. Given this, the dissertation provides guidelines to assist the guitarist in addressing the complexities of tuning the modern instrument in a world where equal temperament is the predominant system of tuning.

**Limits to the Research**

It is not the aim of this dissertation to trace the complete evolution of standardised equal temperament, but rather, to provide an alternative to equal temperament and guidance in respect of tuning *within* equal temperament. However, it is also necessary to place equal temperament in the context of its evolution in order to explain alternative tuning systems. In addition, providing this context is necessary if one is to more deeply understand the complexities of tuning the modern guitar.

\[2\] This is confirmed in Duffin’s *How Equal Temperament Ruined Harmony.*
It is also not my intention to attempt to solve all the problems of tuning the modern instrument. Such an attempt would be futile. Rather, it is intended that researching and discussing the topic will contribute to building a body of knowledge benefitting guitar pedagogy by drawing together some of the disparate sources of information into one document.

**Definition of Terms**

Throughout this paper ‘standard tuning’ refers to the six string classical guitar tuning: E-A-D-G-B and E. Pitches will always be stated lowest to highest. ‘Drop D tuning’ shall mean (D)-A-D-G-B-E. The term *scordatura* (plural: *scordature*) shall be used when referring to any tuning that is different from standard tuning. To assist readability, all *scordatura* pitches will be spelled in order of lowest to highest. *Scordatura* pitches that are different from standard tuning are stated in brackets. For example, the *scordatura* D-G-D-G-B-E is stated (D)-(G)-D-G-B-E.

The terms ‘guitar’ and ‘guitarist’ refer to the classical guitar and classical guitarist respectively.

Strings on the classical guitar are labelled 6th, 5th, 4th, 3rd, 2nd and 1st corresponding to E-A-D-G-B and E respectively.

An ‘open’ chord consists of open strings (unfretted) combined with fretted pitches (and usually played in first position) as opposed to ‘closed’ chords, which have no sounding open strings.
There is considerable flexibility of usage regarding the term ‘tuning’ and this requires explanation. In this dissertation, ‘tuning’ shall refer to the act of adjusting the strings using the appropriate apparatus of the instrument, as, for example, in the following phrase, ‘one is tuning one’s strings before playing the guitar.’ Also, depending on the context, ‘tuning’ may be used as a generic term when describing any system of setting the strings to any temperament or pure tuning system, for example, as in the following phrase, ‘equal temperament is a tuning system, as are Pythagorean and mean-tone systems.’ However, in certain contexts confusion may arise if one does not distinguish between a tuning system and a tempering system. Strictly speaking, systems that use only pure intervals to derive the scale (for example, just and Pythagorean tuning systems) are true tuning systems. Tempered systems are those that compromise the purity of some or all of their intervals to derive the scale (for example, mean-tone and equal temperaments) and cannot be called true tuning systems. \(^3\) Generally, tempered systems, especially, require specific training and experience to master, and this is why today keyboardists employ professional piano tuners to tune their instruments.

The term *cents* is used as a standard point of reference for describing degrees of pitch difference between certain intervals. The term refers to the centile division of an equally tempered semitone into one hundred equal parts. For example, one cent is \(1/100\) of a semitone in equal temperament.

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\(^3\) *Musical Temperaments* by Erich Neuwirth explains this further.
Synopsis of Chapters

This dissertation consists of two parts. Part A (comprising Chapters 1 and 2) places equal temperament within a broader context and provides practical guidance for tuning within equal temperament. Chapter 1 discusses the evolution of equal temperament, its benefits and disadvantages as well as an alternative outlook regarding temperament for the guitar. Chapter 2 discusses some of the guitar literature concerning tuning and, in this context, an informed approach to tuning the instrument is presented along with information about techniques to avoid in order to improve tuning the instrument in general. Part B (Chapters 3, 4 and 5) is a practical guide and commentary examining idiosyncratic difficulties and complexities that influence guitar tuning that are often dismissed within guitar pedagogy. The aim of this section is to offer assistance and solutions for the student and teacher, explaining the various idiosyncratic phenomena by way of practical examples. The dissertation concludes with Chapter 6, which summarises the research undertaken and presents theoretical analysis and modeling of practical solutions.
PART A
CHAPTER 1
TEMPERAMENTS AND AN ALTERNATIVE FUTURE FOR GUITAR TUNING

Pure Intervals and Temperament

Before the time of keyboards and other fixed tone instruments, tuning relied upon intervals that were pure, that is, intervals that matched the natural acoustical relationships corresponding to the harmonic series. In his text broadly considered as the ‘bible’ for tuning and temperament, James Barbour, outlining the principles of Pythagorean tuning, states: “The Pythagorean system is based upon the octave and the fifth, the first two intervals of the harmonic series. Using the ratios of 2:1 for the octave and 3:2 for the fifth ... ” (Barbour 1951:1). Ross Duffin clarifies the relationship to the harmonic series further by stating: “Pure intervals occur when the speed of the vibrations of two or more notes (that is, their frequencies [pitch]) match the simple acoustical ratios of the harmonic series” (Duffin 2007:32).

To clarify this further, a pure octave is an interval perceived as beat-less. This is because an octave has a frequency ratio of 2:1. In mathematical terms, a note corresponding to 440 hertz (vibrations per second) is exactly one pure octave higher in pitch than one vibrating at 220 hertz. There is no disputing whether an octave is in tune, because no matter which tuning system one uses (whether using just or Pythagorean tuning or mean-tone or equal temperament) the octave is always pure. If it is pure, it is in tune, if it is not pure, it is out of tune and not beat-less. A pure fifth has the ratio of 3:2, because the frequency of a note corresponding to 600 hertz is exactly one pure fifth higher in pitch than a note corresponding

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4 For further reading on the harmonic series (overtones) see Rossing’s *The Science of Sound.*
5 Rossing also explains beats in more detail in *The Science of Sound.*
to 400 hertz. These frequencies are not the same that would be heard if the equivalent notes were played in equal or mean-tone temperaments. One would perceive beats because the interval is not pure in these temperaments. Major thirds that correspond to the natural harmonic series require an exact ratio of 5:4 in order for them to be pure and ‘untempered.’ Hence the frequency of a note corresponding to 500 hertz would be a pure major third higher in pitch than one vibrating at 400 hertz. These intervals are pure sounding because by corresponding to the natural ratios of the harmonic series they are beat-less. This means, “that their sounds fit so perfectly together that there is no interference between their respective vibrations” (Duffin 2007:33).

Preserving these natural acoustical relationships “requires that notes have the flexibility to vary pitch according to the needs of the harmony at any given moment, and thus is only possible with voices or on instruments with the capacity to make real-time adjustments as the music is being performed” (Duffin 2007:33). To maintain purity of the major third means G sharp of a major third between E and G sharp would need to be a different pitch from the A flat between A flat and C. Therefore, fixed tone instruments, in order to play in different key centres, need to compromise or temper the purity of the intervals. 6 Mean-tone and equal temperaments were invented for this reason, and it is also why the keyboard has one ‘black key’ corresponding to G sharp and A flat. 7

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6 Keyboard instruments did sometimes have the option to avoid compromising purity by utilising split keys.

7 One must understand that temperaments exist to reduce the comma (discrepancy) which results when one compares the gap between twelve perfect fifths stacked above one another to seven similarly stacked octaves. These two pitches (frequencies) are noticeably different (due to governing mathematical laws). This ‘comma’ is adjusted for in equal temperament by slightly reducing the fifths within each octave to enable twelve stacked fifths to ‘fit into’ seven stacked octaves. If this mathematical principal did not exist there would be no need for temperaments.
The Acceptance of Equal Temperament in Western Music

Equal temperament has been the universally accepted norm for tuning in western music since 1917. Owen Jorgensen states: “After 1917, tempering became a skilled science based on universally accepted mathematical principles, and professional tuners now temper with similar results” (Jorgensen 1991:3). In speaking of piano tuners, Ross Duffin notes that “equal temperament has been a given for generations of musicians through most of the twentieth century and into the twenty-first. They think in equal temperament. They tune in equal temperament. They hear in equal temperament” (Duffin 2007:17). Albert Lavignac also proclaims equal temperament’s status:

Such, with its faults and its merits, is the scale system accepted at the present time in countries the most advanced in civilisation. It is called the equal temperament. Thus, pianos and organs are tuned, and all instruments having fixed tones (Lavignac 1899:53-4).

Equal temperament, in becoming the accepted norm in western music, has led to a disappearance of enquiry into alternative temperaments and tunings. This in turn, has caused western musicians to become satisfied with the impure intervals of equal temperament. As a result, guitarists no longer question their instrument’s tuning system and this has caused interest in alternative temperaments and tunings to disappear almost completely.

Over the history of western music various tunings and temperaments have been used that have led to standardisation of equal temperament. Music dating from before the fifteenth century is thought to have been dominated by Pythagorean tuning, and mean-tone

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8 In Tuning (1991), Owen Jorgensen explains that before the twentieth century, tuning to a mathematically precise equal temperament would have been impossible due to technical reasons. According to Jorgensen, before the twentieth century there were many tuning systems that approximated equal temperament. These ‘approximate’ equal temperaments are called quasi-equal temperaments.
temperament became popular in music after this period (the Renaissance). Mean-tone temperament, in some form, was also used for keyboard instruments between 1550-1650. Irregular mean-tone systems became popular from approximately the late 17\textsuperscript{th} century until equal temperament became, at first idealised after the mid 1800s and then standardised by 1917.

**Temperaments Explained**

A temperament “is a way of tuning the notes of the scale using intervals that have been modified (tempered) from their pure forms” (Duffin 2007:38). Tempering the notes of a scale is needed for instruments possessing fixed pitches and for those capable of chordal harmony. It is also necessary for these instruments as they are unable to alter tuning during performance and hence tuning must be set before a performance begins. If one were to perform using an untempered tuning system (for example, just or Pythagorean tuning) the music would need to be limited in key modulation to sound tolerable. Equal temperament dispenses with these limits, and permits major and minor scales based on the twelve pitches of the western chromatic scale to sound tolerable. Thus, the 24 major and minor keys of the western scale sound equally tolerable.

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9 Refer to Mean-tone Temperament in Barbour’s *Tuning and Temperament*.
10 As stated in Duffin’s *How Equal Temperament Ruined Harmony*.
11 For the purpose of this dissertation the use of the word ‘performance’ refers to the act of playing itself and not the process of giving a concert which usually means pausing between movements or pieces permitting tuning to be corrected.
12 For further information about just and Pythagorean tuning systems see Neuwirth’s *Musical Temperaments* and Barbour’s *Tuning and Temperaments*.
13 For a complete description of equal temperament’s construction refer to Barbour’s *Tuning and Temperaments*. 
Fretted instruments have been tuned in this way from approximately 1550. Mark Lindley states: “Most theorists between 1550 and 1650 regarded lutes and viols as equal-temperament instruments” (Lindley 1984:19) and Louis Jambou concludes: “vihuelists seemed to gravitate toward some form of equal temperament on the fretted instruments by about 1550” (Jambou 1982:130). This is unlike keyboards, which at the time, were tuned in various mean-tone temperaments, the reasons for which are explained later in this Chapter.

The Problem with Temperament

Equal temperament avoids the problem of particular key centres sounding ‘unpleasant’ by tempering all intervals so that none are pure (except the octave), however, in the process, the healing properties and innate responses which a human being has to interval purity are sacrificed. Alain Daniélou on discussing equal temperament’s faults notes:

...Westerners have more and more lost all conception of a music able to express clearly the highest ideas and feelings. They now expect from music mostly a confused noise, [caused by equal temperament’s complete lack of purity across all intervals] more or less agreeable but able to arouse in the audience only the most ordinary sensations and simplified images (1995:122).

This is a strong claim, and there may be validity to the statement. However, if it is completely valid, one must presume that there is no place for any impurity in music at all. With western music’s reliance on temperament, it is difficult to see how one might re-instate all the purity of intervals into music making once more, without turning ones back on half a millennium of western music. This is because, as stated earlier, instruments with fixed tones require at least

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14 The frets of fretted instruments have always generally been set to an approximate equal temperament (and began being tuned this way well before keyboard instruments). In addition, standardised equal temperament evolved as keyboards became more dominant and until then, fretted instruments, to some degree were always able to adapt to different tuning systems according to the needs of the music. This meant that the temperament of fretted instruments was not fixed and because of this, serious players presumably continued to remain aware of the inner workings of its tuning.
some form of temperament in order to play in different keys (as these instruments are inflexible regarding adjustment of tuning during performance). To not use temperament, would require one to limit the scope of one’s repertoire to music written prior to the 1400s. Music written by Franz Schubert, Johann Sebastian Bach, Wolfgang Amadeus Mozart, Claudio Monteverdi, John Dowland, Henry Purcell, Giovanni Gabrieli and so on, all require fixed tone instruments to be tempered. While it may not be possible to reinstate all the purity of intervals into western music, it is my argument that it is possible to regain a significant amount through the use of certain mean-tone temperaments.

**Mean-tone and Irregular Mean-tone Temperaments**

As composers began to incorporate thirds into their writing, (for example in the early renaissance) it was considered important to preserve their purity on the keyboard. A particular sort of mean-tone temperament called quarter comma mean-tone became popular in the renaissance and was designed to uphold the purity of the thirds; however in doing so, it necessarily sacrificed the purity of the fifths. This is because in constructing the standard quarter comma mean-tone temperament “the four intervening fifths must all be narrow by quite a lot since they ‘create’ the major third” (Duffin 2007:34). Quarter comma mean-tone was also not ideal because it had eight pure thirds and four extremely intolerable ones and because of this, some key centres still remained intolerable and thus unusable.

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15 The very need for temperament was prompted by the invention of fixed toned instruments in the first place.
16 If one did not use temperament, discrepancies would occur because interval types would be of different sizes between the pure tuning of pre renaissance music and that of music using various temperaments that came after this.
17 For further background on quarter comma mean-tone construction see Duffin’s *How Equal Temperament Ruined Harmony.*
Fortunately, the invention of *irregular* mean-tone temperaments solved this problem. Irregular mean-tone temperaments were built by ‘tweaking’ all the fifths and thirds slightly differently, making each key tolerable, but *not equally* tolerable. The result is the *same* interval type being different in size in different keys. For example, a major third in E major might be physically larger than in the key of D flat major or a minor third in D minor might be smaller in size than one in F minor. In this system, unlike in equal temperament, each key centre has its own particular ‘flavour’ and expressive character, and, perhaps more significantly, the purity of many of the intervals is restored without limiting the instrument’s register or key.

**Recovering the Sensitivity of the Western Ear**

Today, the western ear is completely saturated with the sounds derived from the almost exclusive use of the equal temperament system. The result of this is that most of us have lost sensitivity to the resonance and beauty of intervals that are acoustically pure. This means that anyone who is exposed to western civilisation for long enough will have their ears similarly compromised. Overall, this has meant that, in general, western musicians and listeners, regardless of origin, have either forgotten, or are unaware of the interesting and expressive character differences of other tuning systems (for example, just, Pythagorean and mean-tone systems). This is unfortunate as these tunings and temperaments have much to offer the human being.

It is argued by Alain Daniélou that “… a perfectly accurate [pure] interval not only acts on our ears but also produces a transformation in all the cells of our body … ” and “This effect was used to cure certain diseases.” For this reason he also states: “disregarding small

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18 For further information about various *irregular* mean-tone temperament systems see Barbour’s *Tuning and Temperament*. 
differences in intervals has very grave consequences with regard to the deeper effect of music” (Daniélou 1995:8). It appears that if westerners keep disregarding these small differences (by continuing to use equal temperament exclusively) then we will continue to miss out on the true healing qualities of music.\(^{19}\)

In order to rectify this, what is needed is re-sensitisation and re-training through education of the western ear in the appreciation, value and sensitivities of a broader repertoire of tunings and temperaments.

**Application of Irregular Mean-tone Temperament to the Guitar**

Amongst the variety of music performed today, there would be room for making music in temperaments other than in equal temperament.\(^{20}\) One need not be limited to equal temperament purely because it is the accepted norm. I argue, there is currently a need for western musicians to question their acceptance and exclusive use of equal temperament and for musicians to *decide* which tuning or temperament is appropriate depending on the requirements of the repertoire being performed. For example, it would be a more interesting, varied and healing listening experience if Johann Sebastian Bach’s ‘Preludes and Fugues’ from the *Well Tempered Clavier* were performed using a ‘well tempered’ irregular mean-tone temperament. This would enable all the contrasting expressive characters of each key to be heard and increase the effectiveness of the music to arouse sensations within the human organism through the partial re-instatement of interval pureness.

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\(^{19}\) In *Music and The Power of Sound*, Alain Daniélou describes that a perfectly accurate interval (pure according to its natural acoustical relationships) can produce “a slowing down or acceleration in the movements of every molecule in ourselves” (1995:8), an effect that was put to use in musical traditions of ancient Greece, India, Persia and Arabia. Daniélou also discusses the work of Muhammed Hafid, who assigned specific musical scales to heal diseases.

\(^{20}\) Interestingly, a modern reference to tuning the guitar to mean-tone temperament is found in Reinhart Frosch’s book, *Mean-tone is Beautiful!*
Historically, ‘good’ irregular mean-tone temperaments (for example, ones which are difficult to tune but sound more tolerably in tune across all the keys) have always been difficult for keyboardists to use due to the complexities involved with tempering them. On the other hand, the fretted guitar can be ‘prepared’ relatively easily for an irregular mean-tone temperament with the aid of interchangeable fretboards (set to the desired temperament). With the appropriate fretboard in place it would be possible to tune the strings of the instrument to intervals of an irregular mean-tone temperament. The performer would no longer be limited for an entire concert to a single temperament; the option of making a relatively simple substitution of fretboard (with frets set to just or Pythagorean tuning or equal temperament) would open up new worlds of programming possibilities for guitarists as well.

Re-structuring of the guitar’s neck design to allow for fitting of different tempered fretboards would also facilitate performances of early music in the temperament or tuning in which it was conceived. Using different fretboards would permit the vihuela and lute music of certain composer’s music to be played using the original tunings or temperaments for which they were written. For example, the music of Luys Milan could be performed using mean-tone temperament (the temperament for which it is arguably intended) and performing John Dowland’s music would be possible using a tuning similar to his variation of Pythagorean tuning.

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21 See Duffin’s How Equal temperament Ruined Harmony for further reading about the problems with tuning different irregular mean-tone systems, and see Barbour’s Tuning and Temperament for a detailed analysis of irregular systems of temperament.

22 See Frosch’s Mean-tone is Beautiful for the preparation of a type of mean-tone tempered guitar.

23 Barbour explains John Dowland’s Pythagorean lute tuning and Lindley refers to Luys Milan’s mean-tone temperament.
A different option for allowing flexibility of temperament would be the construction of a fretboard to facilitate the use of adjustable *individual* frets corresponding to *each* note (instead of the standard fixed straight frets) which enable the performer to make necessary changes to the temperament according to the repertoire needs. Today, with technological advances it would be more possible than ever to achieve such a system.

At present the *standard* construction of the guitar does not incorporate the use of different fretboards or individual frets for each note. Further research investigating design and construction methods enabling this would be most desirable and beneficial for bettering the future of guitar playing and its place in re-sensitising the western ear to the beauty and healing properties which the varied tunings and temperaments have to offer.
CHAPTER 2
PROBLEMS WITH THE EXISTING PEDAGOGICAL LITERATURE

Where is the Knowledge?
Given that most guitarists are not aware of the history and inner workings of tuning and do not question their own tuning methods, it is not surprising that, today, there are only a few disparate sources of knowledge regarding the tuning of the instrument. Most of the accurate and useful knowledge is either buried in literature not directly pertaining to the modern instrument or, is not easily accessible, and the easily accessed knowledge is brief or perfunctory. Therefore, the purpose of this dissertation is to contribute to the body of knowledge by bringing together, into one document, some of the sources of existing useful knowledge on the topic.

For the remainder of this dissertation all tuning discussion will apply to the modern equally tempered guitar.

Unquestioned and Accepted Norms
The strings of the modern guitar are pitched from lowest to highest, E-A-D-G-B-E; three fourths, followed by a major third, followed by another fourth. Many experienced guitarists tune their instruments with a mixture of harmonics, octaves, unisons, fifths and fourths, using interval purity as the guide to whether an interval is in tune or out of tune. Depending on the method used, the result can (albeit unreliably) be agreeable across most of the fretboard. Many also check the open E chord with the open C chord (or other method for checking the

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24 However, if a guitarist has a reliable method producing an agreeable tuning, it is usually discovered through trial and error and not based on thorough knowledge of the intervals of equal temperament.
3rd string) to hear if the ‘problematic 3rd string’ is adjusted well enough for both of these chords to sound agreeable. Predominantly, this method is unquestioned.

It is my claim that guitarists need further knowledge and training about the compromises of interval purity required to tune the guitar to equal temperament. Most guitarists, in my experience, naturally gravitate to tuning intervals pure, but tuning in this way conflicts with what is required for equally tempered frets. The question for guitarists is, what degree of compromise is necessary? I argue that guitarists need adequate tuning literature to provide guidance on this issue, and future pedagogical publications need to address tuning in light of this.

**Methodologies Examined**

Aaron Shearer, in *Classic Guitar Technique Volume 1* (a method widely used for teaching purposes world wide), instructs the student in the method of checking tuning using unisons. This method, also recommended by John Playford in 1674, indicates tuning the strings by matching unisons between adjacent strings.25 One usually begins this method by tuning the 6th and 5th strings to a perfect unison. One then tunes the 4th string to the previously tuned 5th string. In a similar manner, the 3rd string is adjusted to match the 4th string and so on. This method does not guarantee an accurate compound E octave between the outer 6th and 1st strings, since unisons on an equally tempered guitar require a subtle compromise in their purity.26

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25 This procedure is clearly stated in Meffen’s *A Guide to Tuning Musical Instruments.*

26 Conventional fretboards are not designed to account for pitch idiosyncrasies that result when strings are depressed to the frets. Thus, it is not advisable to tune using intervals involving open and closed strings.
Aaron Shearer recommends to “... make a final test by playing this [open] E major chord” (1963:7). He later claims in the same section when discussing the E chord: “This is, without a doubt, one of the most beautiful major chords on the guitar if the instrument is in tune; it should have a thoroughly pleasant sound with absolutely no feeling of discord” (Shearer 1963:7). Tuning the guitar using an E chord that is almost pure in its intervals (as the above statement implies) is likely to result in an instrument playable only using the notes of that particular E chord. In addition, the probability of this outcome is further increased when one is unaware of the degree to which one must compromise purity regarding tuning an instrument in equal temperament.

The author Pascual Roche in *A Modern Method for the Guitar – School of Tarrega*, a proponent of the famous Francisco Tarrega school, instructs the player to tune using a method similar to that described by Shearer. However, Roche does not recommend the use of the open E chord as a final check. One must assume that Roche and Shearer received no tuition regarding superior methods of tuning other than that stated in their publications (for a superior method refer to *Solution: A Reliable Method for Tuning the Guitar to Equal Temperament* on page 23 of this thesis). In the methods offered by Shearer and Roche, no accounting for fret temperament or of the true inner workings of tuning the instrument are mentioned.

The authors of the publications above make a significant omission by not mentioning that the guitar's frets are set to standard equal temperament. Thus, if one tunes to pure intervals (a practice most guitarists embrace) then one will be disregarding the *impure* intervals required for equal temperament. For example, tuning the 3rd string and 2nd string (G and B) too close
to a pure (narrow) major third will not account for the much wider major third required for equal temperament.

The precision required for equal temperament is demonstrated by the following:

An instrument designed to play in equal temperament lacks perfect consonances, except for octaves. The player could also be in conflict with the instrument in tuning. If the frets imply equal temperament and the instrument is tuned in fourths with the addition of one major third, these intervals would have to be tempered (by two and fourteen cents too wide, respectively); if not, the method of tuning will not meet the intention of the frets (Meffen 1982:122).

This statement’s content is almost always dismissed as part of guitar tuning pedagogy and it would be very rare indeed to hear any teacher, student or professional discuss tuning similarly in these terms.

For a guitar to be tuned according to equal temperament, the player must temper the strings. Tempering requires extensive training and much experience to master, as any piano tuner will affirm. Given this, it is an anomaly that guitarists are expected to have the necessary skills to tune the strings of their own instrument with little or no training or specific pedagogical literature to refer to.

It is worth noting that the published methods cited in this dissertation are pitched essentially towards the beginner and technically complex information regarding tuning the guitar would not be helpful for a student engaged at the very early stages of learning to play the instrument. However, it would be a welcome addition to any methodology if some
elementary concepts and skills required for tuning and tempering were included in pedagogical publications of the future.

**Solution: A Reliable Method for Tuning the Guitar to Equal Temperament**

It must be noted that the ear generally detects interval tuning discrepancies when a pitch being adjusted is tuned from a point which lies lower in pitch than the desired final resting point. Therefore, one must always *raise* a pitch (being tuned) to its final resting point, instead of lowering it from above. In addition, this approach is more reliable because it avoids mechanical inaccuracy caused by most standard guitar tuning machine heads when they are used to lower a pitch from above the final resting point. Detecting tuning accuracy is also significantly improved by dampening sympathetically vibrating strings which may sound during tuning. This is achieved by positioning the left and right hand fingers on the appropriate strings to prevent sympathetic vibration.

Perceiving the presence of beats is a fundamental part of determining the accurate tuning of octaves. One must practice hearing them in order to become proficient at tuning the guitar. Because notes on the guitar decay quickly it is common for only a few beats to be heard (unless the pitch is very out of tune) at the beginning of the note when the energy in the string is high. More beats can be heard as the note dies but they are significantly more difficult to hear than at the beginning of the note. Often beats are perceived as disharmonious ‘fighting energy pulses’ at the very beginning of the note. If one is sensitive enough, one can feel this ‘flurry’ of energy in the body of the instrument. One should adjust any string being tuned to cause the beats to slow in frequency. The slower the beats are, the closer the interval is to being pure and in tune. The beats will slow to a point where one can perceive them no longer.
As this happens, one needs to listen for lessening disharmonious energy and an increasing presence of undisruptive ‘clean’ and pure sound.

Often lacking in discussions of tuning, is the importance of producing a consistent and resonant sound with the nails of the right hand. It is vital, when tuning, that one takes as much care with sound as one would when performing a piece of music. Without this attention to sound, the ear can be easily misled and distracted by inconsistent timbral qualities. Producing a resonant sound is also essential if one is to excite one’s instrument enough to allow the perception of beats.

When attempting to tune the guitar, one must decide upon an appropriate selection of fretted intervals which offer sufficient resonance to enable one to adequately hear the presence and speed of beats. Such intervals are located on the 4th and 1st strings at the 7th and 5th fret respectively (the pitch A). These notes should be resonant on most guitars, and appropriately, both are fretted (as distinct from using a mixture of open and fretted notes and harmonics). The notes should be played at exactly the same time.

When listening to the octave’s tuning it is very useful to alternate between the sound of the next octaves higher and lower in pitch (using the same fingering ‘shape’). For example, one needs to sound octaves on the notes G, G#, Bb, B and C as well as A. This technique keeps the ear ‘fresh’ and assists in keeping second-guessing from hindering perception. One should persist until the octave is adjusted so that it is beat-less. Because the energy of notes sounded on the guitar fade relatively quickly, it is crucial to replay the octave very frequently to

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27 It is arguable that many of the misleading tuning methods described earlier in this chapter arise from an intuitive search for more resonant intervals with which to tune (satisfying the need to find an easier tuning method). However, methods which use resonance as the only guide for deciding tuning intervals will always be ‘hit and miss.’
enable maximum perception of ‘beat energy.’ When the octave is beat-less it will be perceived as a ‘calmness’ and ‘harmoniousness’ between the two notes of the octave. It will also lack any disruptive energy caused by the presence of beats.

One should apply the same principals to tuning the lower octave (the note A) between the 5th fret of the 6th string and the 7th fret of the 4th string. Once this is completed one should check for accuracy by cross-referencing the low A of the 5th fret 6th string to the high A (previously tuned) on the 5th fret 1st string. All three notes should be sounded at exactly the same time. At this point it is important to keep checking other pitches using the same fingering to preserve ‘freshness’ of the ear. A final check of these two octaves should be executed by playing all three notes together (using the same fingering ‘shape’) shifting the pitch along the fretboard to check for accuracy across the range. Once this has been completed the 5th, 4th and 2nd strings remain to be tuned.

To tune the 2nd string, one sounds the note a 4th below the high A by playing the 5th fret of the 2nd string (the note E). One should do this at the same time as playing the note a 5th below this note on the 4th string (the note A). This will help the guitar to ‘sing’ with resonance and assist with perceiving impurity of the intervals. Again, one is listening for a ‘calmness’ and harmoniousness characterised by a distinct lack of ‘fighting energy.’ Listening for a ‘clean’ and ‘pure’ sound is crucial. Likewise, shifting this tuning ‘shape’ along the fretboard is essential for maintaining ear ‘freshness’ and for checking accuracy across the entire fretboard range. Once the 2nd string has been tuned, use it to tune the octave below (E on the 7th fret of the 5th string) using the same method for perceiving purity.\footnote{For simplicity and practicality the author argues that it is sufficient to tune using pure 5ths and 4ths instead of tempered ones. The tempering of these intervals in equal temperament (to which the frets are set) is negligible (approximately 2 cents smaller for 5ths and 2 cents larger for 4ths) that any successful attempts to temper these intervals are unnecessary.}

Check for the purity of this
string by sounding four strings together (E-7th fret 5th string, A-7th fret 4th string, E-5th fret 2nd string and A-5th fret 1st string). The sounding of these strings with a resonant tone at precisely the same time will greatly assist the ear in perceiving the purity of all the intervals. It is also prudent to maintain the shifting of the pitch of the tuning ‘shape’ across the fretboard to preserve ear ‘freshness.’ One may also wish to play some of these notes combining the 6th string low octave (the note A) as a precautionary reference. At this point the 3rd string remains to be tuned.

Tuning thirds on the guitar requires perception without reference to beats. This is because beats of thirds sounded on the guitar are very difficult, if not impossible, to hear. The 3rd string is also the only one requiring significant tempering. Reliable tuning of the 3rd string requires recognition of pure and impure major thirds using pitch perception alone.

This skill is practiced by sounding an open E chord (a resonant chord on the guitar) and lowering the 3rd string (the third of the harmony) to a pitch the ear recognises as the limit of tolerability. This pitch will be within a close margin of a pure major third. One should experiment with lowering the string further down in pitch than tolerable. When the third becomes noticeably intolerable, raise the pitch to the point at which it becomes tolerable once more. With careful listening and fine adjusting, it is possible to achieve a beautiful, ‘singing’ quality (which accompanies pure sounding major thirds) in this interval.

The third string is more challenging to tune because it is the only string that requires such compromising of purity (tempering). In equal temperament, the interval of the third is the

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intervals would be thwarted by the instrument’s tuning idiosyncrasies across other areas. It is also arguable that efforts to temper the 5ths and 4ths would be impractical and inaccurate without suitable training, equipment and tuning apparatus. Due to natural resonances on the guitar, a deviation of 2 cents would be virtually impossible to differentiate.
most *impure* of all the intervals (it is much sharper than pure thirds). In addition, the third string is also under the influence of idiosyncratic properties caused by the string’s mass and tension, therefore, one must never use an exclusively singular chord or tuning ‘shape’ to tune the 3rd string. Instead, one must cross-reference between two to three differing chords in order to tune the 3rd string suitably.

Begin tuning the 3rd string by sounding the lowest four strings of an A major bar chord at the 5th fret. This combination of intervals allows for an easier perception of tuning the 3rd string. Adjust the string to be tolerable, but not too low so as to sound pure. Sound a C major chord in open position and listen for the tuning of the open third string. The pitch of this string (open G) needs to be sufficiently low to enable a tolerable fourth between the open G and the 1st fret C on the 2nd string, and sufficiently high in pitch to enable a tolerable major third between the 2nd fret E on the 4th string and the 1st fret G# on the 3rd string. These intervals must be tolerable but not pure. The precise point at which one rests the 3rd string is a personal decision based on the tuning needs of the music and context within which one is performing. However, one must never set a string at a pitch creating a pure third between the 4th and 3rd strings of an open E major chord or pure fourth between the 3rd and 2nd strings of a open C major chord. Instead, one must compromise by choosing a point halfway between both.

At this point, the strings of the guitar should be well tuned and the intervals tolerable in most situations. However, there are many idiosyncrasies that need to be accounted for to bring a guitar more tolerably in tune in certain configurations of left hand fingering. These will be discussed in part B of this dissertation.
**Tuning Habits to Avoid**

It is appropriate at this point to underline some ‘habits’ to be avoided when tuning the guitar. It is impossible to find a completely watertight method for completely successful tuning, however one can be certain about tuning habits one needs to avoid when tempering the strings of the guitar. These are presented below and some will already be familiar to many guitarists who take great care with tuning.

**Harmonics**

Plucked instruments are, by nature, rich in harmonics, and the resonant qualities of the guitar that reinforce and prolong many of these harmonics make the process of listening for beats aurally tiresome. Logic suggests that tuning with natural harmonics (for example, 12\(^\text{th}\), 7\(^\text{th}\) and 5\(^\text{th}\) fret harmonics), which are pure sounding and not open to being obscured by other resonances and harmonics that the guitar may or may not highlight or prolong, would be a favourable practice. In the past, this may not have been the case. According to John Meffen, strings are rarely manufactured with the required consistency to enable correct harmonics to sound from any natural harmonic plucked on the instrument. However, Meffen’s work was published almost thirty years ago. Strings today are being manufactured using modern materials and methods, and it *may* be possible today to tune reliably using natural harmonics.

**Pure Intervals**

In equal or irregular mean-tone temperament, it is logical that one should tune by ensuring that the octaves are pure. However, it is not advisable to apply the same approach to the tuning of other intervals. For example, if one tunes the guitar using pure fifths this would not account for the requisite tempering of the fifths (for equal or irregular mean-tone temperaments). In equal temperament, the fifths are slightly narrower than pure by two cents
and should be tuned slightly smaller than pure. Likewise, fourths should also not be tuned pure, as fourths are larger in equal temperament. If tuning to equal temperament, thirds must not be tuned pure, as equally tempered major thirds need to be exactly fourteen cents larger than pure tuned ones. However, in an irregular mean-tone temperament, the thirds, fourths and fifths will vary according to the particular key centre.

**Tuning Using Open and Fretted Notes**

The pressure created when stopping notes on the frets increases the pitch by approximately one cent, with greater variation occurring according to the fretboard region in use. It is reasonable to assume that if guitar scale lengths are adjusted by luthiers (guitar makers) to compensate for this phenomenon, then fretboards should produce true equally tempered notes. However, it is unlikely that guitar scale lengths are adjusted to completely accommodate this across the entire fretboard. Therefore, using open strings with stopped notes to tune is likely to be flawed.

**Compounding Tuning Methods**

It is common for elementary school students to begin learning to tune using the unison method frequently outlined in many guitar methods for beginners. This method is described briefly in Chapter 2. Using this method, one usually begins by tuning a string to a reference pitch such as a tuning fork. After this, one proceeds by tuning the next adjacent string to its unison by stopping the 5th fret of the string previously tuned to the reference pitch. Once this pitch has been successfully tuned, one stops the 5th fret of this string and adjusts the next string to a perfect unison, and so on, until all the strings have been tuned. As discussed in Chapter 2, this method is always flawed due to its failure to account for the idiosyncrasies of
the instrument. Any method that depends upon the accuracy of tuning pure intervals successively, string by string, is not a reliable method.
PART B
CHAPTER 3
IDIOSYCRATIC TENDENCIES AFFECTING TUNING OF THE GUITAR

The guitar is riddled with idiosyncrasies and instabilities that thwart the best of tuning methods. These problems make the tuning of the guitar (while accounting for all these idiosyncrasies in the process) very difficult indeed, and prevent the practice of setting the strings only according to standardized equal temperament. In addition, the guitar is unable to make real-time tuning adjustments, thus increasing the burden all guitarists must face when tuning their instruments before a performance begins. The intention of Part B is to provide guidance to enable guitarists to better understand the complexities and difficulties involved with tuning and how better to cope with them in the concert performance itself.

Solutions to problems caused by tuning the strings to various scordature (including the use of a capo) are also presented as part of these idiosyncrasies.

The ‘Problematic Third String’

As stated in Chapter 2, many guitarists commonly check tuning using the open C and open E chord in order to ascertain the aural tolerability of the third string. Many players use this check (or similar) without knowing the nature of the problem and why the check is necessary.

The third string’s mass and diameter (in cross section) is the greatest of the treble strings. It is also a string under one of the least amounts of tension. Being of greater mass and diameter it “exhibits a proportionally greater propensity toward pitch sharpening when it is pushed out

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29 Modern materials and new varieties of 3rd string diameters will allow better compensation for the idiosyncrasies that influence the conventional 3rd string. However these alternative strings affect the tonal qualities of the string.
of line down to the fret” (Cumpiano 1993:327). When playing a pitch close to the nut (such as the G sharp on the first fret) the string is at its most tight and requires more finger pressure to sound a clear note relative to other positions on the string. This combination of elements causes the first fret of the 3rd string to exhibit a strong tendency for being sharper than it might otherwise be if fingered elsewhere on the fretboard. Under the influence of a higher action, this effect would be further increased (due to the increased forces needed to push the string further down to the fret). This particular problem highlights the need to ensure one’s action is well adjusted to allow both chords’ tuning tolerability. It also highlights the need for the performer to be well aware that one cannot tune using a standard equally tempered G sharp of an E chord as this may cause the open G in the C major chord to sound noticeably flat (caused by the above elements no longer influencing the tuning of the open 3rd string of the C chord).

The sensitivity of the third string to this tendency is unique to the G sharp on the 1st fret (and sometimes extends to the A on the 2nd fret) and is caused by the close proximity to the nut. Conversely, the 6th and 5th strings become sharper the further one plays away from the nut, highlighting the complexities of this idiosyncratic tendency.

**Fretting System Problems**

There are two predominant mathematical systems for determining the placement of the frets. The ratio of any given note to its upper octave is 1:2. Therefore, the octave pitch frequency above a note is always determined by multiplying it by a factor of 2. Given that the octave in equal temperament is divided into twelve equal semitones, one must use a formula for determining each semitone frequency. The 12th root of 2 supplies a decimal that represents the ratio between two adjacent semitones. This ratio is 1.0594631. For example, to obtain the
frequency of an equal semitone above the frequency of 220 hertz, one multiplies this number by the above decimal. The frequency obtained by multiplying 220 by this decimal is 233.08188. This process is then repeated to obtain the next semitone frequency and so on until all twelve semitone frequencies are determined. As Cumpiano states: ‘The relationship of the scale length [string length] to the first fret interval is therefore 1.0594631 divided by 0.0594631’ (Cumpiano 1993:267). This division equals 17.817152. When one divides this number into any given scale length it produces the distance from the nut to the first fret. Successive divisions into remaining scale lengths produce further fret placement intervals. This system does not account for the tightening effect when the string is pushed to the fret.

A second alternative system for determining fret placement is the “Rule of Eighteen.” This system is best summarized by Cumpiano’s statement:

It is unlikely that many of the early luthiers were familiar with twelfth roots or mind-numbing decimal fractions. Instead, they relied on a far simpler rule…using the whole number eighteen as the fret constant. If 18 is used as the fret constant [instead of 17.817152], however, the twelfth fret will end up slightly further away from the saddle than the midpoint of the scale [string length]. This is because 18 will make each fret interval about one percent smaller than will 17.817[152] [the number used for more precise fret placement according to equal tempered semitones]. The net effect produced by using the Rule of Eighteen, then, is that the notes will play progressively flatter up the fingerboard. Interestingly, however, this flattening effect partially counteracts the tightening (sharpening) of the string when pressed to a fret. Thus, the rule provided a rudimentary form of internal compensation to the scale (1993:267).

The Rule of Eighteen has been used for centuries past, whereas the more ‘accurate’ system of precise decimal measurements derived from the 12th root of 2 (used for equal temperament) is
the more accepted method used today (provided that luthiers add an adequate compensation factor when locating bridge placement).

The Rule of Eighteen “… has been most prevalent in the setting of the frets since its use by Vincenzo Galilei (1581)” (Meffen 1982:127). Meffen also notes: “Galilei discovered that by setting each fret in the ratio of 17:18, he got nearer to an equal tuning for each string than by setting them in any other method”30 (1982:127). Mark Lindley also refers to Galilei’s method, adding: “… it is likely to give a better approximation than the 12th root of 2, because the latter figure makes no allowance for the fact that pressing the string to the fret increases its tension and so yields a higher pitch than the change in length alone would lead one to suppose” (1984:21). However, according to Rossing and Cumpiano, standard practice for luthiers today appears to be the accurate decimal resulting from the 12th root of 2. Luthiers counteract the forces exerted on the string from pressing the string to the fret by increasing the scale (string) length by a small amount. Given this, a guitar should sound relatively in tune according to equal temperament as long as one has accounted for all of the above idiosyncrasies, but this is not the case.

Rossing, discussing string compensation, states:

Bass strings require more compensation than treble strings, and steel strings require considerably more than nylon strings. A guitar with high action (larger clearance between strings and frets) requires more compensation than one with a lower action. Some electric guitars have bridges that allow easy adjustment of compensation for each individual string (1990:212).

30 Regarding the spelling of ration in the quotation, it is possible that the spelling of this word is intended by the author, although the more conventional spelling would be to omit the letter n.
Cumpiano’s description of bridge placement on steel-string guitars is also relevant in this discussion:

A distinguishing characteristic of the steel-string bridge is its slanted saddle slot. This feature provides additional length for the bass strings. This is necessary because as the string increases in mass and in cross-section, it exhibits a proportionately greater propensity toward pitch sharpening when it is pushed out of line down to the fret (1993:327).

Referring to Rossing’s statement, a guitarist would without doubt find that nylon strings require less compensation than steel strings. The player of the nylon stringed instrument may thus draw the conclusion that the compensation required is small enough to justify no saddle ‘slanting.’ On the contrary, when one plays the nylon string guitar, the effect is heard in particular regions of the instrument and is worthy of compensation. This effect is evident when one frets notes on the 6th and 5th bass strings in higher positions of the fretboard (approximately the seventh fret and above).

This phenomenon is caused by the higher action exacerbating the string displacement factor (which to some extent is present on every note of the fretboard) combined with the propensity for bass strings (with greater mass and cross section) to sound sharper when pressed down to the fretboard. Steel-string and electric guitars, because of their greater susceptibility to the above problems, have structural and mechanical alterations that have solved these problems. However, there appears to be little or no effort to effectively solve these problems on the classical guitar. If a saddle slot on a steel-string guitar is slanted significantly, it would make sense to find ways of achieving a similar adjustment to current saddle placement on the classical instrument without compromising or interfering with its acoustical properties. The already difficult task of tuning could be made less arduous for the player by such an innovation.
String Compensation: An Example of a Solution

In the absence of such structural compensation on modern classical guitars it becomes necessary for the *player* to compromise the tuning of the bass strings. One needs to do this only when playing chords that are particularly displeasing in the higher positions (for example, root position major triads with the root on the 6th string). It is suggested that the player check the ‘offending’ chord/s and adjust the appropriate string enough to reduce the intonation of the displeasing chord/s without compromising the tuning of other chords or intervals in other regions of the fretboard. Also worth mentioning at this point is that one needs also to be mindful that the ear’s tolerability to highly ‘compromised’ intervals can be greatly increased when they are combined with other intervals. One should bear this fact in mind when finding suitable methods to solve problems of this nature.

To illustrate an approach to this adjustment, an Eb major chord with the root, third and fifth respectively on the 6th, 5th and 4th strings shall be examined. If one plays this chord without compromising the tuning, the resulting sound will be quite displeasing to the ear as the root and third will sound very sharp when compared to the fifth on the 4th string, a situation caused by the influence of factors discussed above on pages 28 and 29 on the 6th and 5th strings in particular. In order to counteract this effect, one might sharpen the 4th string very slightly and flatten the 6th by the same amount. The 5th string may also be flattened slightly, but may not need as much due to the *combination* of intervals rendering the third to sound more tolerable despite it being very ‘out of tune.’ If the strings in question are adjusted in this opposing way, one avoids skewing other areas of fretboard intonation by an intolerable amount at the same time as enabling chords which are most influenced by these factors to be played with more tolerability.
Different *scordature* (to *mistune*), in addition to being very common, are important for guitarists and composers in achieving a number of musical goals not possible in standard tuning. These include: extending the range, altering the instrument’s resonance and character, as well as increasing the number of open strings harmonically important in a particular key centre. In addition, in the majority of cases, all of these factors combine to facilitate better ease and fluency resulting in a more enhanced listening experience for the player and listener.

**Drop D Tuning: An Example of a Common Scordatura**

By far the most common alteration to standard tuning is known as ‘drop D tuning,’ whereby the low E string is tuned down a complete tone to the pitch of D. This tuning is most often used for pieces composed, transcribed or arranged in the key of D and is particularly resonant. This is because all of the bass strings, usually set to E-A-D, are changed to (D)-A-D. This pitch set is more strongly related to the key of D and greatly increases the resonance and character of the instrument. In addition the root and fifth of the key are accessible using open strings, better enabling the left hand to focus on melodic and harmonic material in different areas of the fretboard.

The importance and prevalence of drop D tuning cannot be emphasised enough. It has become so utilised today, that it is extremely difficult to find a concert program that *does not* involve drop D tuning. Given this, it is very surprising that relatively few people, if any, actually teach an adequate method for successfully executing different *scordature*. Again, I have witnessed many concerts given by students and professionals in which *scordature* have
been enough out of tune to be noticeable, and this suggests an insufficient education regarding this tuning skill.

**The Challenges of Executing Scordature in Concert**

*Scordatura* shifts which need to occur within a concert program present particular challenges to the player. Apart from the normal difficulty in shifting one’s focus away from the music to the rigors of adjusting the tempering of the strings, one is faced with the extremely difficult task of managing strings that continually re-adjust after having their tension (stress) dramatically altered for a *scordatura*. If one does not address this adequately before commencing a piece, a player will almost certainly be forced to cope with an intolerable ‘creeping’ out of tune of the strings, especially if the duration of the piece is longer than just a few minutes. If one does not have a suitable opportunity to adjust an offending string in real time, the consequences of the string continually ‘creeping’ out of tune can impair listener satisfaction as well as greatly distract the player from the focus needed for performing. Indeed, I have witnessed too many concerts where this has been a severe problem to ignore it in this dissertation.

In order to better understand how strings react when they are subjected to changes in tension (stress) as required by *scordatura* one needs to be better informed about the properties of the materials with which strings are made.

According to Thomas Rossing, modern guitar strings are usually monofilament nylon (a type of polymer) for the trebles and nylon (polymer) cores wound with metal for the basses. It will be assumed, for the purposes of this dissertation, that bass and treble strings both being manufactured from nylon, will react in approximately the same way to different stresses. The
evidence for this is in the ability of bass strings to remain at a constant tension despite the metal winding being partially absent (and therefore not exerting influence on string tension). For this reason the following discussion will deal with the physical properties of nylon only.

**Properties of Polymers (Nylons)**

Nylon is a type of polymer. Polymers are used for many purposes including building, aircraft and automobile components, bridge components, tyres, food packaging, stockings, clothes, electrical insulation and of course, guitar strings. The reason guitar strings and many other items are made from nylon is due to certain physical properties exhibited by polymers. These include: toughness and resistance to wear and tear, moisture repellence (compared to natural substances), precision and consistency of manufacturing and elasticity.

When the stress (tension) applied to a polymer is changed (placed under a different tension) the “...strain [the string’s opposing resistance to a new tension] on the material will not be constant but will increase slowly with time” (McCrum *et al* 1988:101). Effectively, when a nylon guitar string is slackened in tension (for example, with drop D tuning), the strain on the string does not equal the stress immediately after the adjustment of the string. “On release of the stress [such as loosening a string], the molecules slowly recover their former spatial arrangement and the strain simultaneously returns to zero [the string ‘settles’]” (McCrum *et al* 1988:101). The strain discussed here can best be described as: the altered state of the molecules (caused by a change in stress) slowly becoming ‘settled’ and fully ‘recovering’ as the material finds its own equilibrium. This recovery would apply to tuning in the following way: as a string ‘rearranges’ itself after being loosened or tightened, the effect on pitch would be to immediately rise after being loosened and to immediately lower after being tightened. Because the molecular restitution of the string (or molecular ‘creeping’ process) takes
considerable time, it is not complete in the time it takes for tuning to be executed and continues once a piece has begun. This leaves the player in the undesirable position of ‘coping’ during the performance. A better outcome would be to find a way of hurrying the process of molecular rearrangement during the tuning process itself so that the molecular ‘creep’ during performance is minimised as much as possible.

A Method for Coping with String ‘Creep’

As stated above, string ‘creep’ inevitably occurs when adjusting strings to *scordatura*. In order to eliminate this as much as possible one needs to find a method for accelerating the ‘creeping’ process before commencing a piece.

My proposition for achieving this is based upon many years of experience using the principle of Boltzman Superposition, which describes the adding together of individual stress increments to reduce the ‘memory’ effect caused by a given stress history. For example, if one needed to reduce the stress (tension) upon a string and induce a more rapid ‘creeping’ back process, one would reduce the stress (tension) on the string further than that required for the *scordatura*. Thus, one adds a new increment of stress to that required for the *scordatura* stress, causing the string to ‘forget’ part of its former stress history and allowing ‘settling’ of the string into a new tension more quickly. The only alternatives to this method are to ‘cope’ with ‘creep’ during performance by carefully adjusting the string in an appropriate moment in the middle of a piece (which is highly distracting) or wait for a given length of time for the string to ‘settle’ in the tuning process (not possible during most concert performances due to the length of time required).
For further clarity, let us explain the above method in the context of describing a guitarist’s most common scordatura: drop D tuning.

**An Example of Method for Tuning a Simple Scordatura: Drop D Tuning**

To begin, one lowers the low E string to the pitch of D for a brief moment. Taking this temporary D tuning peg position as a starting point (first increment of stress), one loosens the tuning peg down two further 180-degree turns (second increment of stress). Once this has been achieved, one should continue to check the rest of the strings and carry out any tuning needed while leaving the over-compensated 6th string to ‘settle.’ It is advisable to *not* hurry the checking and tuning of other strings in order to allow as much time as possible for the tension ‘memory’ to be ‘forgotten’ by the string. Once tuning of the other strings has been completed, one should bring the over-compensated 6th string up to the destination pitch of D. Then, the 6th string D should be tuned to a perfect octave with the open 4th string D. After this octave has been matched, allow for further ‘creeping up’ in tension that will still occur to a lesser degree with the 6th string (despite the considerable compensation already applied) by setting the 6th string very slightly below a perfect octave (approximately 2-3 cents). This allowance should be adjusted enough to provide leeway for further ‘creep’ while also preserving most of the purity of the perfect octave. This method should ‘settle’ the 6th string sufficiently for a piece or movement of several minutes to be played without the need for ‘emergency’ adjustments during its performance.
Summary of Method: Drop D tuning

1. Lower the 6th string to the pitch of D.
2. Starting at this peg position, lower the tuning peg two further 180-degree turns (one 180-degree turn for each semitone the string is being lowered from its original pitch; in this case two).
3. Tune the other strings as needed.
4. Bring the 6th string up to a perfect octave below D using the 4th string as a reference.
5. Set the 6th string tolerably below the perfect octave to allow for further ‘creep.’

The table above describes the steps necessary for re-tuning a string down in pitch. The same steps applied in the opposite pitch direction should be used for a scordatura which requires a re-tuning of a string up in pitch. Also, as a general rule, for every semitone which a string needs to be re-set away from its standard pitch there should be one 180-degree twist of the tuning peg past the destination pitch to compensate for normal string ‘creep.’

Complex Scordature

Tuning one or two strings for a scordatura is usually the most one needs for the majority of pieces requiring scordatura. Commonly, setting a scordatura involves shifting the pitch of one or more strings away from standard tuning by the same interval and in the same pitch direction. However, occasionally scordature require different directions of pitch alteration or different intervals of pitch alteration or a combination of both. Because tuning of this nature involves careful listening and multiple steps of varying adjustment of each string, it is advisable to practice the adjustment steps rigorously if one is to reliably, quickly and accurately set the strings to their new pitches during a concert. Due to the complexity of this
task, adequate practice of a complex *scordatura* is essential; if one has to think too consciously about each step, it is easy to find oneself under considerable stress-inducing pressure in the concert environment. In addition, when well practiced, a performer is much better positioned to undertake the task of setting a new *scordatura* in the shortest possible time with the most accuracy, thus avoiding overly lengthy breaks or disruptions between pieces in a concert program.

One can use the steps in Table 1 for tuning and *compensating* each individual string. As long as adequate time is left for the re-tuned strings to ‘settle’ before bringing them to their destination pitches, one should encounter much less string ‘creep,’ facilitating the *scordatura* to remain in tune for a more suitable length of time. It is also advisable for strings needing re-setting the largest interval away from their standard pitch to be adjusted and compensated *before* others. This enables them to ‘settle’ as much as possible, before being brought to their respective destination pitches.

**Re-tuning Scordature to Standard Tuning**

Adjusting strings *back* to standard pitch also requires compensation. While strings may still be adjusting little by little in a *scordatura* well after one has tuned adequately, the string is significantly ‘settled’ in this new pitch (tension) and requires as much care in re-setting to standard pitch as for *scordatura* pitches. For instance, when returning the 3rd string from F# to G, it is best to adjust the tuning peg to the pitch of G and apply a further 180-degree twist of the peg to compensate for the new tension required by the standard pitch.
Complex Scordature: Programming and Practice

Generally guitarists agree that in concert it is best not to program pieces requiring different complex scordature consecutively. This prevents tuning difficulties but also provides better flow in programming by avoiding too many tuning pauses between pieces. It is not, however, always possible to sidestep consecutive complex scordature in concert programming. If one does need to undertake this, a particularly effective use of time involves discretely adjusting the strings that need re-tuning for the next scordatura as one is acknowledging the audience. This requires that the player, without aural cues, know very instinctively through practice how many turns each tuning peg needs in order for each string to be adjusted appropriately for the scordatura. This familiarity is usually achieved fairly easily once one becomes practiced and confident with the outlined method previously described in Table 5.1.

The above discussion may seem to be taking the process of compensating for string ‘creep’ a bit too far. Admittedly, it is important that the performer not appear to be distracted while acknowledging the audience. Finding discrete ways of adjusting the tuning pegs requires practice and careful thought. Considering the benefits of avoiding undue string ‘creep,’ such care and practice are necessary to ensure tolerable tuning when performing pieces requiring different scordature.

The Use of the Capo

A particularly common practice for playing Renaissance music involves the placement of a capo on the neck at the 3rd fret. The purpose of this is to raise the pitch of the guitar’s strings by a minor third to match the tuning and/or sound of the Renaissance lute. There are
arguments for and against this practice, and one should consider them before deciding to play with or without a capo.  

When using a capo, it is necessary to consider the idiosyncrasies discussed in Chapter 3. For instance, the required fretting pressure between the new ‘open’ 3rd string Bb and the 1st fret B natural may be less than when not using a capo. Also, the 6th and 5th bass strings may need to be tuned slightly flat in order to compensate for their greater tendency to be affected by pressure exerted when the string is pushed down to the fret.

In addition, fixing a capo to the fretboard prevents strings (especially bass strings) from sliding easily underneath when the string is adjusted using the tuning pegs, due to the rubber of the capo ‘gripping’ the string when its tension is changed. This ‘gripping’ effect requires that the capo must be lifted off when adjusting the strings. The use of a capo that allows quick ‘on and off’ during tuning adjustments is therefore advised.

A detailed and precise method for tempering the strings when using a capo will not be discussed further, however with knowledge of the various peculiarities specified in Chapters 1 to 4, one should have sufficient background to successfully tune using a capo.

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31 Arguments for the use of the capo include: clearer voicing (due to reduction in resonance caused by the ‘dampening’ effect of the capo) and change in the register that is ‘refreshing’ for the ear when used in a concert program. The arguments against the use of the capo are: one sacrifices volume (due to the ‘dampening’ of resonance) and sustain (due to notes in the higher register decaying more quickly).
One can divide western instruments into a number of categories based on the control one has of tuning during performance. Stringed instruments, the voice and the trombone have the most freedom, as these instruments possess no fingering devices to assist with fingering or slide positioning. Woodwinds and most of the brass family have necessarily limited control of tuning in real time with keys and valves to assist the player in achieving equal temperament. Most keyboard and tuned percussion instruments have no control over tuning during performance, and there are the fretted instruments that occupy a somewhat problematic place in the real time tuning category.

Fretted instruments are inherently difficult to tune because there is an immensity of freedom to adjust tuning when not playing but very limited freedom during performance. This limited freedom during playing makes the task of tuning the guitar an extremely challenging one because one cannot respond to any peculiarities or idiosyncrasies of guitar tuning as they arise in the act of playing. Instead, this can only be done prior to commencing a piece, in the pre-performance tuning process itself. Therefore tuning of the guitar needs to be exercised with extreme care and accuracy. Given this, along with technological advances, the option to respond to tuning during performance could be enormously beneficial, unfortunately such technological innovations are not available for the classical instrument and here remains an opportunity for luthiers to possibly improve the instrument.

Although one cannot apply any strategies as a means for actively adjusting tuning during performance, one can prevent disagreeable tuning in certain areas by applying certain
techniques of the left hand. Providing the setting of the strings is correct, it is best to consider these techniques as measures that ensure tuning does not ‘stray’ from what might otherwise be good tuning.

**Left Hand Fretting Pressure**

We have learned in Chapter 3 that bass strings and strings with greater mass and cross-section have a propensity to exaggerate the sharpening effect caused by pushing the string down to the fret. In addition, a higher action increases this effect. In certain areas of the fretboard these particular properties can be easily exacerbated if one is not careful to make sure ones fingers are exerting minimal pressure on the strings that are affected.

A particularly clear example of this technique is found in bar 40 of William Walton’s ‘Bagatelle III’ from *Five Bagatelles* for solo guitar (1974:9). The first chord of this bar involves a challenging combination of fingering and potential for intolerable tuning. The C and G in this chord are fingered on the 6th and 5th bass strings respectively (with the potential to sound sharp), the B is played using the open 2nd string (with the potential to sound flat compared to fretted notes) and the E is fingered on the 3rd string. The chord is also played in a high position (where strings sit the highest above the fretboard and are the most loose in tension). Even in relatively ‘unstrained’ circumstances this chord could sound tolerably out of tune. However, due to the particular difficulty executing this chord, one is easily tempted to apply further downward finger pressure to the frets than is necessary. When this happens, potential for it to sound out of tune comes to bear upon the chord for the reasons stated in Chapter 3. In addition, greater finger pressure causes the fingers and hand to ‘stretch’ bass strings laterally adding to tuning inaccuracy. To counteract this problem, one needs to concentrate efforts at reducing downward pressure on the strings and frets as much as
possible. This technical application also has the added benefit of generally enhancing the fingers’ accuracy and reliability for executing chords of similar nature.

It is an oversimplification of guitar technique to assume that merely reducing one’s downward pressure on the strings will correct the issues discussed above. One’s technique must also be developed sufficiently to allow relaxed, controlled and independent movement between the fingers when one executes difficult chords such as this. A technique that permits such flexibility is only reached after many years of intelligent, methodical practice aimed at achieving poised finger independence. Aside from improving tuning, this is something any serious guitarist should engage with if interested in improving playing skills in general.

**Lateral String ‘Stretching’**

An additional factor influencing tuning when executing difficult chord shapes is the tendency for fingers to ‘grab’ and ‘pull’ strings in the direction of the length of the string. This effect is one of ‘stretching’ notes out of tune and is principally a problem when fingerings involve the bass strings. The cause of this is the metal winding of the bass strings acting as ‘grip’ for the left hand finger calluses to ‘imprint’ themselves on. When this happens, any lateral finger movement along the length of a string which occurs while fingerling a fretted bass note will ‘stretch’ the note significantly out of tune. The chord in bar 40 of ‘Bagatelle III’ from *Five Bagatelles* is also prone to this ‘stretching’ particularly at the point of melodic fingerling that occurs after the chord is positioned (Walton 1974:9). Because this melody and chord combination involves significant agility and relaxed finger independence for even the most advanced players, the two bass notes C and G will in all cases be dramatically affected unless fret pressure and lateral ‘gripping’ is greatly reduced. One executes this by practicing ‘arrival’ onto such a chord with completely dissipated left hand tension and applying only the
minimal required pressure to the strings necessary for sounding the notes clearly during the melodic passage that follows the chord placement. This in turn assists finger flexibility and agility and prevents the rigid ‘finger gripping’ caused by callus ‘imprint’ which ultimately causes lateral string ‘stretching.’

In addition to the above, it must be noted that when in higher positions, all strings are at their most loose in tension. This fact alone will cause bass strings, in particular, to be very susceptible to lateral string ‘stretching’ caused by finger callus ‘gripping.’ Hence, the need to apply the technique stated.

The Effects of Temperature on Tuning

Because the guitar is generally unable to actively respond effectively to real time tuning alterations there should be utmost care taken to ensure temperature does not fluctuate significantly between off-stage and on-stage environments. Polymer viscoelasticity is highly dependent upon temperature for stability of molecular structure (and hence pitch stability). This means if the temperature changes between on and off-stage, strings will adjust through a performance as molecules re-arrange according to the degree of alteration in temperature.

Prior experience has illustrated that a solution is to ensure one’s instruments remains on stage (or as close to as possible) through the entire duration of the performance. This guarantees temperature stability and is particularly effective at reducing tuning delays when performing in ensembles using multiple guitars (tuning more than two guitars can be particularly time

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32 The precise meaning of viscoelasticity as stated in Principles of Polymer Engineering by McCrum et al is: the solid is elastic in that it recovers but is viscous in that it creeps.

33 For further technical information regarding exactly how temperature affects the viscoelasticity of polymers see Principles of Polymer Engineering by McCrum et al.
consuming). Unfortunately, keeping one’s instrument on or near the stage is not always possible due to variations in performing environments. In such an event, one must ensure that the temperature off-stage matches (as closely as practically possible) the temperature on-stage through the use of appropriate air conditioning or heating devices.
CHAPTER 6
CONCLUSION

Standardised equal temperament, which relies upon impure tuning of certain intervals, is the accepted tuning system in western music today. I argue that this practice has led to a diminished appreciation of music, and, if one agrees with Alain Daniélou, that western music, as a result, has lost not only its potential to heal, but also its ability to incite within us the deeper feelings, images, and sensations that characterise human experience.

To recover this ability, musicians and audiences need to be re-acquainted with the subtleties of the tuning and tempering systems that existed prior to the advent of standardised equal temperament. By recovering our awareness of pure musical intervals, the experience of the healing and expressive qualities of music, that are to this day still present in the rich musical cultures of India and parts of the Middle East, will be accessible to everyone.

For guitarists, unquestioned acceptance of equal temperament, along with the introduction of fixed frets, has left them no longer knowledgeable about the guitar’s complex inner workings regarding tuning. Possible remedies to this situation include:

- The introduction of pedagogical publications that discuss all available temperaments and tuning options.
- The restructuring of the instrument itself, in particular, of the neck design, to incorporate interchangeable fretboards set to different tunings and temperaments or to offer individually adjustable frets for each note on the fretboard.
● A commitment on the part of educational institutions to provide training in all systems of tuning for all students.

Ultimately, problems associated with tuning the guitar will be resolved when guitarists (and all musicians) fully understand and appreciate the acoustical and mechanical properties of their instruments, become conversant with the complete body of repertory available to them (including works from the pre-standardised equal temperament era), and devote themselves to the study and contemplation of these issues as aspects essential to and inseparable from the experience and performance of music.
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