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Gravitonicity: towards a model of the ‘Gravitation’ in Music

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Abstract

This research develops a model of the 'gravitation' in Music. In the literature on the 'gravitational' properties of melody and harmony, two sub-metaphors are apparent: 'distance' and 'motion'. Gravitation and Music's 'gravitation' are, therefore, fundamentally separate categories. To benefit from the metaphor without equating the experience of the two, Music's 'gravitation' is designated as 'Gravitonicity'.

The model is developed from three questions: 'What is Gravitonicity?'; 'How and to what extent is it possible to derive a model of Gravitonicity from the 'neutral level' (Nattiez, 1990, pp. 12)?' (e.g., music theory); and 'How does the listener construct the meaning (Nattiez's 'esthesic dimension') of Gravitonicity and to what extent can this lead to a subjective experience?'.

Conceptual metaphor theory (Lakoff and Johnson, 1980; 1999) is used to argue that the 'distance' is metaphorically shaped by our embodied understanding of physical distance. Steve Larson (2012) uses the same approach to explain the 'motion' alongside music-theoretic explanations.

Music-theoretic explanations of the 'distance' have been historically sporadic and with little consistency in approach. Addressing this lacuna, spectral analysis is undertaken in conjunction with Chord Scale Theory (as taught at Berklee College of Music) to reveal 'Gravi-Tone Series'' (GS'): specific mappings of twelve distance ('*g*') values onto all twelve pitch classes ('gravi-tones'). It is argued that the GS' are attributed by a four-quality psychological process entitled 'Gravi-Tone Series Filtering' (GSF). With a unifying perspective on all types of scales, harmony, and functionality, GSF potentially belongs to the general theory of music.

John Shepherd and Peter Wicke's 'Semiological Model' (1997, pp. 173) is used to extrapolate meaning construction, illustrating how Gravitonicity may be negotiable for 'different individuals and in the same individual at different times (pp. 175). Finally, further details of the model are uncovered through its analytical application to the chord-melody jazz guitar repertoire.

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Glossary

Active Mass Significance (AMS): Gravi-tones can accrue additional 'mass' / significance from motion (AMS). Steve Larson identifies 'three melodic forces' (2012, pp. 12) as the sources of motion: 'musical gravity' (pp. 82), 'melodic magnetism', and 'musical inertia'. As section '3.17: Distance and Motion: RMS and AMS' explains, these may also be conceived of as the G, M, and I axes / dimensions of Gravitonicity.

Avoid Note(s) (AN('s)): Gravi-tones that are more distant from *g*1 than the Chord Tones (CT's) and Tensions (T's), but closer than the Upper Tensions (UT's). Avoid Notes (AN('s)) are 'nonchord tones which are *a half step above* a chord tone' (pp. 26). The inclusion of AN's in a harmonic structure can lead to varying degrees of friction in Gravi-Tone Series Filtering's (GSF's) processing that may be likened to dissonance or instability.

Chord Scale Theory (CST): Comprised of 'chord scales' (Nettles and Graf, 1997, pp. 17) and how they relate by 'function' (pp. 30) to the various harmonic contexts of tonality, modality, blues, and so-called 'nonfunctional relationships' (pp. 162). The chord scales are scales and/or modes for which the constituent tones are organised into 'three qualities' (pp. 17): 'Chord Tones' (CT's), 'Tensions' (T's), and 'Avoid Notes' (AN's). This represents a pre-existing framework that mirrors the function of the *g* values (distance).

Chord Tone(s) (CT('s)): The closest gravi-tones to *g*1, usually assembling a type of seventh chord.

Chromatically Altered Chord Scale GS: A Gravi-Tone Series (GS) in which one or more notes of the chord scale (Chord Tones / CT's, Tensions / T's, Avoid Notes / AN's) has/have been raised or lowered by a semi-tone.

The Full Model of Gravitonicity: The full model houses responses to all three research questions: what Gravitonicity is, the 'neutral level' (Nattiez, 1990, pp. 12) model, and the role of the listener's subjective experience.

Function(s) / Functionality / Functional Relationship(s): The functions of Gravitonicity are Gravi-Tone Series' (GS'). It is argued that the sequential arrangement of GS' constructs the functional relationships of tonality, modality, blues, and 'nonfunctional relationships' (pp. 162).

Gravitonicity: The 'distance' and 'motion' in harmony and melody. It is named after the physical gravitation metaphor and the relative 'tonicity' (tonic potential) / distance of the gravi-tone (*g*) values.

Gravi-tone(s): An appropriation of the term 'graviton' (Rothman and Boughn, 2008) (the hypothetical quantum of gravity) to designate pitches as the mediators of Gravitonicity. The twelve gravi-tones are represented by the Chord Scale Theory (CST) scale degree numbering system and traditional pitch names.

Gravi-tone value(s) (*g* value(s)): Measurements of distance (rated on a scale of 1-12 (*g*1-*g*12)) that are mapped onto the gravi-tones: *g*1 acts as the 'central star' (Hindemith, 1941, pp. 57) whilst the gravi-tones that contextually embody *g*2-*g*12 represent the 'close to distant relationship' (Russell, 2001, pp. 3) from *g*1.

Gravi-Tone Series(') (GS(')): Specific mappings of the twelve gravi-tone (*g*) values onto the twelve gravi-tones. Gravi-Tone Series' (GS') are the functions of Gravitonicity and the outputs of Gravi-Tone Series Filtering (GSF).

Gravi-Tone Series Filtering (GSF): A psychological 'feed-forward' (Gordon, 1995, pp. 185) 'filter' that attributes Gravi-tone Series' (GS') by analysing four qualities of the 'Input' sound: the present tone(s), their harmonic spectra, memory traces of preceding tones; and the unified time dimension (Z axis). Gravi-tones that are mostly strong represented by the four qualities have ‘boosted’ gravi-tone (*g*) values (closer to *g*1), whereas those which are weakly represented are ‘attenuated’ (closer to *g*12).

Gravitonic: Relating to Gravitonicity.

The ‘Neutral Level’ (Nattiez, 1990, pp. 12) Model of Gravitonicity: A music-theoretic description of how ‘the musical text’ gives rise to our constructed meaning of ‘distance’ and ‘motion’.

Presence: Primarily used in the spectral analysis sections of Chapter 3 as an ‘esthesic dimension’ (Nattiez, 1990, pp. 12) / perceptual equivalent to the decibel (dB) levels of the harmonic spectra. It is organised into four tiers: strong presence (SP), consisting of dB levels between -20 and -39; medium presence (MP), dB levels between -40 and -49; weak presence (WP), dB levels between -50 and -59; and no presence (NP), dB levels including -60dB and below.

PT(‘s): An abbreviation of ‘present tones’ used in the spectral analysis sections of Chapters 3 and 4.

Rest Mass Significance (RMS): The distance of Gravitonicity. As section ‘3.17: Distance and Motion: RMS and AMS’ explains, the Rest Mass Significance (RMS) inhabits Gravitonicity’s X, Y, Z, and T axes / dimensions.

T Axis / Dimension: Time.

Tension(s) (T(’s)): Gravi-tones that are more distant than the Chord Tones (CT’s), but closer than the Avoid Notes (AN’s) and Upper Tensions (UT’s). Tensions (T’s) are ‘Additional tones which create special sound colors and tension’ (Nettles and Graf, 1997, pp. 17).

Upper Tension(s) (UT(‘s)): The most distant gravi-tones from *g*1, existing outside of the ‘chord scales’ (Nettles and Graf, 1997, pp. 17) and completing the chromatic collection. They have been classified and used by the composer Miroslav Spasov as a complement to Chord Scale Theory (CST) that brings ‘additional nuance to the sound, extra tension, new character, etc’ (Pejovski, 2021 – unpublished manuscript).

X Axis / Dimension: The monophonic succession of pitch events.

Y Axis / Dimension: Multi-layered super-imposed pitch events.

Z Axis / Dimension: A unified time dimension that conveys the inter-relationships between harmony and rhythm.

Chapter 1: Introduction

Yet there—in fields of space—is where she shines,

Ring-mistress of the circus of the stars,

Their prancing carousels, their ferris wheels

Lit brilliant in celebration. Thanks to her

All's gala in the galaxy.

- A stanza from 'Gravity' (1990, pp. 13) by John Frederick Nims.

The metaphor of gravitation has historically been used to express how we understand and experience certain properties of harmony and melody. This connection was first made by Jean-Philippe Rameau in *Génération harmonique* (1737), published only half a century after Sir Isaac Newton's Universal Law of Gravitation in *Philosophiæ Naturalis Principia Mathematica* (1687) ('The Mathematical Principles of Natural Philosophy'). Although Rameau was the first to use the metaphor, discourse on the 'gravitational' properties of music can be traced back to the Ancient Greeks; not unlike the pre-Newtonian recognition of gravitation by figures such as Aristotle (384-322 BCE) and Galileo Galilei (1564-1642 CE).

However, whereas the study of gravitation has enjoyed the breakthroughs of Newton, Albert Einstein (1920), (arguably) string theory, and LIGO's detection of gravitational waves (2016), there have been no analogous milestones for the study of Music's 'gravitation'. The literature for the latter (reviewed in Chapter 2) has been historically sporadic and with little consistency in approach – an important exception being a short twentieth-century lineage with interest in the harmonic series.

Moreover, whilst there have been some significant individual contributions, no single work or theorist has produced a ‘complete’, systematic model of Music’s ‘gravitation’ that offers a perspective on the existing literature and addresses the lacunae. It is this gap that motivated this thesis which, in response to the following research questions, aims to decipher what Music’s ‘gravitation’ is, model it, and account for the listener’s subjective experience. ‘Gravitonicity’ and Jean-Jacques Nattiez’s terms are discussed further down the page.

RQ1: What is Gravitonicity?

RQ2: How and to what extent is it possible to derive a model of Gravitonicity from the ‘neutral level’ (Nattiez, 1990, pp. 12)?

RQ3: How does the listener construct the meaning (Nattiez’s ‘esthesic dimension’) of Gravitonicity and to what extent can this lead to a subjective experience?

Chapter 2 will illustrate that other metaphors for Music’s ‘gravitation’ have been used since Ancient Greece. The gravitation metaphor has been used in this research for several reasons, including: its frequent historical and contemporary usage; the omnipresence of physical gravity means that its properties are intuitively understood at a universal level; several of the key figures in the field and their contributions tend to be common knowledge (e.g., Newton and the apocryphal apple); the research into physical gravity brings an effective array of terminology and detail to the metaphor; and the two types of gravitation share a similar all-encompassing nature.

Despite some metaphorical correlation, however, it is not a 1:1 relationship. In actuality, the literature reviewed in Chapter 2 will demonstrate that Music’s ‘gravitation’ is experienced as ‘distance’ and ‘motion’. The ‘distance’ will be the focus of this research whereas the understanding of ‘motion’ will be drawn from Steve Larson’s *Musical Forces* (2012). Larson’s work uses conceptual metaphor theory (Lakoff and Johnson, 1980; 1999) to argue that the ‘motion’ is metaphorically shaped by our embodied understanding of physical motion in the material world. Similarly, this thesis will argue that the ‘distance’ is metaphorically shaped by our embodied understanding of physical distance.

Gravitation and Music’s ‘gravitation’ are, therefore, fundamentally separate categories. However, gravitation will be retained as the umbrella metaphor – subsuming distance and motion as sub-metaphors – to effectively profile and bring character to Music’s ‘gravitation’. From this point on, as shown by RQ1-3, Music’s ‘gravitation’ will be referred to as ‘Gravitonicity’. This name retains the essence of the gravitation metaphor without metaphorically equating the experience of the two. There will be a more detailed exposé of its meaning in Chapter 3.

The distinction between the RQ2 and RQ3 accounts of Gravitonicity is based on Jean Molino’s ‘Semiological Tripartition’ (Nattiez, 1990, pp. 10), as adopted by Jean-Jacques Nattiez. Molino and Nattiez propose three dimensions of symbolic phenomena in music:

> (1) ‘The poietic dimension’ (pp, 11), which is concerned with the ‘process of creation’ and the factors which influence it e.g., historical, political, social etc.
>
> (2) ‘The esthesic dimension’ (pp. 12), involving the reception of symbolic phenomena by the ‘receivers’ and their attribution of meaning(s) to it/them. However, Nattiez notes that ‘‘receiver’’ is [...] a bit misleading. [...] we do not ‘‘receive’’ a message's meaning (since the producer intended none) but rather construct meaning’.
>
> (3) The ‘neutral level’, which is the physical and material embodiment of the ‘symbolic form’ (e.g., the musical text), typified by Nattiez as a ‘trace’ and by Molino as the ‘niveau neutre [neutral level] or niveau matériel [material level]’. Nattiez states that

> ‘an objective description of the neutral level can always be proposed – in other words, an analysis of its immanent and recurrent properties’. Such an ‘objective description’ requires the ‘poietic and esthesic dimensions of the object’ to be ‘“neutralized”’ (pp. 13) and for the analytical tools to be ‘systematically exploited’.

The model produced in response to RQ2 will ‘neutralize’ the ‘poietic’ (pp. 11) and ‘esthesic’ (pp. 12) dimensions to provide ‘an objective description’ of Gravitonicity at the ‘neutral level’. The ‘neutral level’ model identifies pitches – metaphorically styled as ‘gravi-tone(s)’ – as the mediators of Gravitonicity (‘distance’ and ‘motion’). Their ‘distance’ is attributed by a psychological ‘filtering’ process – styled as ‘Gravi-Tone Series Filtering’ – which accounts for present tone(s), their harmonic spectra, memory traces of preceding tone(s), and a mysterious unified time dimension. Steve Larson’s (2012) conception of ‘motion’ will be positioned as a separable component of the ‘neutral level’ (Nattiez, 1990, pp. 12) model.

However, because we ‘construct meaning’ in the ‘esthesic dimension’, it cannot be completely ‘neutralized’ (pp. 13) by the ‘neutral level’ (pp. 12) model. Instead, the model offers a music-theoretic description of how ‘the musical text’ gives rise to meaning construction through our experiential application of the ‘distance’ and ‘motion’ metaphors. It is argued in Chapter 3 that the application of these metaphors may have a significant (if not universal) cultural reach. It is also acknowledged that some cultures may use other metaphors or experience music without meaning.

The purpose of RQ3 is to build upon the ‘neutral level’ (Nattiez, 1990, pp. 12) model of Gravitonicity by extrapolating how meaning is constructed in the ‘esthesic dimension’. This is achieved by drawing upon the ‘Semiological model’ (1997, pp. 173) from John Shepherd and Peter Wicke’s *Music and Cultural Theory*. Their work is used to frame and weave a semiological strand through the ‘neutral level’ (Nattiez, 1990, pp. 12) model and the metaphors. This creates space for a ‘SLIPPAGE’ (Shepherd and Wicke, 1997, pp. 173) or ‘Negotiation’ (pp. 174) of meaning ’in different individuals and in the same individual at different times (pp. 175).

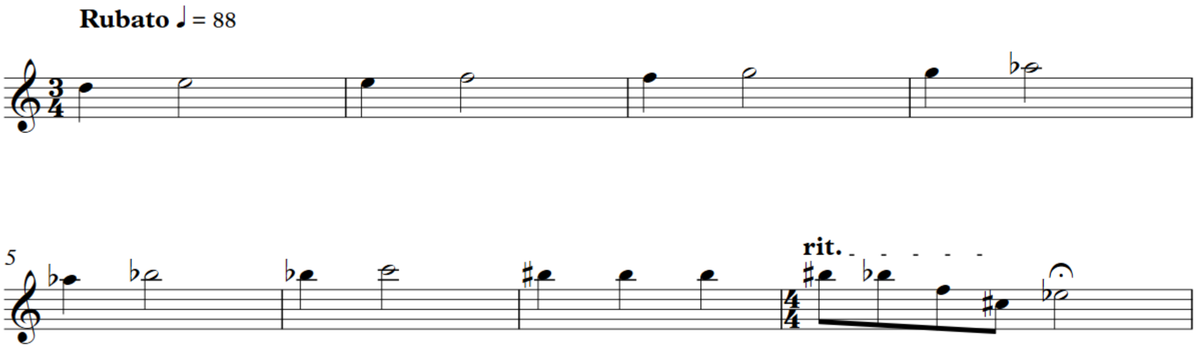
Together, the ‘neutral level’ (Nattiez, 1990, pp. 12) model and the extrapolated ‘esthesic dimension’ form the full model of Gravitonicity. Both models are aimed to be of value to practitioners, analysts, and educators from all musical backgrounds. Chapter 4 will uncover further details of the models through their analytical application to the chord-melody jazz guitar repertoire.

Molino and Nattiez’s ‘poietic dimension’ (pp. 11) is not addressed because it would shed no further light on how Gravitonicity works or is experienced. Moreover, perhaps because Gravitonicity has been an unsystematised property of music, creators’ accounts of it can be difficult to trace – particularly for individual pieces and bodies of work. In future research, however, such accounts could provide interesting access points from which the analyst proceeds to apply the models assembled here.

1.1: Dimensioning Gravitonicity

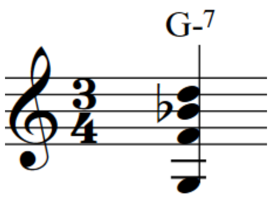
The ‘neutral level’ (Nattiez, 1990, pp. 12) of Gravitonicity will be observed, analysed, and systematised within a framework of dimensions that is mentally assembled in the act of listening. To an extent, these dimensions are graphically represented by the axes of music notation. Where they are not, they will be illuminated in Chapter 3. The dimensions / axes include: the monophonic succession of pitch events (X axis); multi-layered super-imposed pitch events (Y axis); a unified time dimension that conveys the inter-relationships between harmony and rhythm (Z axis); time (T axis); and a set of further dimensions that each house a different kind of ‘motion’.

Example 1.1a illustrates the X axis with the isolated melody voice of Wes Montgomery's (1961) introduction to the jazz standard *Angel Eyes* (Dennis and Brent, 1946).



Example 1.1a: The melody (X axis) of Montgomery's introduction to *Angel Eyes* (1961).

In discussions of melody and harmony, it is common to see this axis referred to as 'horizontal'. This label is not used in this research because, whilst the monophonic line undoubtedly moves horizontally across the stave, there is also a verticality in the ascents/descents of pitch. Example 1.1b illustrates the Y axis with the chord Montgomery uses to harmonise the first melody note of *Angel Eyes* (1961).



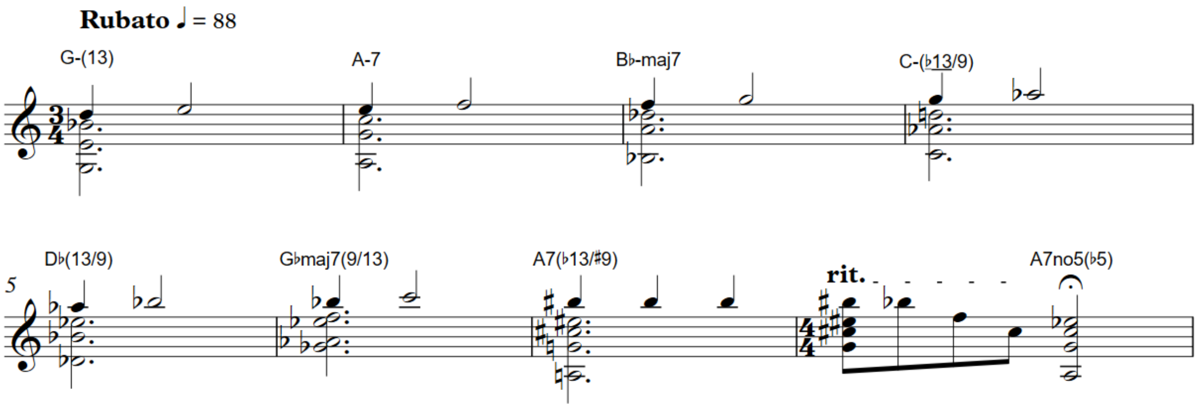
Example 1.1b: Montgomery's harmonisation (Y axis) of the first melody note of *Angel Eyes* (1961).

In a similar fashion to the X axis and the 'horizontal' label, it is common to find the Y axis being referred to as 'vertical'. This is as equally problematic as the 'horizontal' / X because any example of multi-layered super-imposed pitch events possesses a duration and is thus not a strictly vertical or 'frozen' phenomenon. The duration necessitates the inclusion of the time (T) axis. Moreover, each of the tones in the chord may be understood as melody voices i.e., individual X axes.

Music in general can exist in three combinations of the four dimensions named thus far. The first 'combination' is a lone T axis which may be characterised by silence, such as John Cage's *4'33''* (1952), or music in which there is an absence of discernible pitch to populate an X or X and Y axes. The second combination is realised when the passage of time (T) is decorated with a monophonic succession of pitches (X), which may also enable the unified time dimension (Z): X/Z/T. Finally, the third dimensional combination (X/Y/Z/T) introduces the multi-layered super-imposed pitch events (Y) which, once unified with the other axes / dimensions, opens the door to the remaining homophonic, heterophonic, and polyphonic textures.

Because properties of harmony and melody will be the focus of this research, the first dimensional combination will only be addressed in the context of memory i.e., the 'empty' space following pitch content. Similarly, whilst dimensional combination two will be found and discussed in the analyses, the general presence of the Y axis in most music throughout history and from all over the world – including the super-imposition of a melody and drone – means that dimensional combination three will predominate.

Example 1.1c shows this combination of the X/Y/Z/T dimensions through a re-arrangement (Shufflebotham, 2020a) of Montgomery's introduction to *Angel Eyes* (1961). The combination of X and Y can be understood as the Y axis building harmony into the monophonic line (X), or the X axis enabling successions of the multi-layered super-imposed pitch events (Y). Whilst the time (T) dimension is discernible from the tempo marking and rhythmic values, both it and the unified time dimension (Z) will receive additional explanation and analytical strategies in Chapter 3. The ‘motion’ dimensions will also be discussed in Chapter 3.



Example 1.1c: A re-arrangement (Shufflebotham, 2020a) of Montgomery’s introduction to *Angel Eyes* (1961), demonstrating X/Y/Z/T axes. The approach to chord symbols will be explained deeper into the text.

1.2: The Evolution of Harmony in Western Music

A fundamental claim made by this research is that Gravitonicity is an inherent part of all music in which pitch has a discernible presence. It is not a theoretical construct or the result of an arbitrary harmonic development, rather it is present in music of all times. To support this claim, this section will provide an historical account of how harmony has evolved in Western music. The major evolutionary stages of this account will be cross-referenced as Gravitonicity is modelled in Chapter 3. Unless specified otherwise, the dates and historical records which follow have been drawn from *A History of Western Music* (Burkholder et al., 2014).

The earliest historical records of Western music are the Babylonian writings (ca.1800 BCE) which indicate knowledge of intervals and a seven-note diatonic scale with a corresponding modal system. Either directly or indirectly, these theoretical components influenced the theorising and practice of the Ancient Greeks: Pythagoras (ca.580–ca.500 BCE) is credited with the relation of concordant intervals to ratios; Aristoxenus' *Elementa Harmonica, Book II* (1990 – first documented ca.330 BCE) distinguished between melodies, intervals, and scales; and Cleonides (dates uncertain) is recognised for documenting the modes, relating them to their "ancient" names and/or 'styles of music practiced in different regions of the Greek world' (Burkholder et al., 2014, pp. 18) e.g., Dorian, Phrygian, Lydian etc.

The modes can be traced into the first millennia CE through the early Christian Church and the eight modes or echos (pl. echoi) of Byzantine chant, which 'served as a model for the eight modes of the Western Church' (pp. 28). However, the Church modes would retain none of their Greek names (instead being numbered as 'Mode 1', 'Mode 2' etc) – despite the Roman scholar Boethius (ca.480-ca.524) re-exploring the teachings of Ancient Greece – and gained additional functions e.g., authentic/plagal versions, finals, and reciting tones.

Boethius' work was ultimately acknowledged in the ninth century as writers began to apply the Greek names to the Church modes. However, the writings were misread, and the modes were labelled incorrectly. As a result, there is no connection between the Greek and Church versions of, for example, the Lydian mode.

The next significant development occurred ca.850–ca.900 with the documentation of the Y axis in the anonymous theoretical text '*Musica enchiriadis* (Music Handbook) and an accompanying dialogue, *Scolica enchiriadis* (Comments on the Handbook)' (Burkholder et al., 2014, pp. 39). These works use the term 'organum': 'two or more voices singing different notes in agreeable combinations according to given rules' (pp. 85). Although organum 'was apparently already an old practice' by the time these works were published and the use of a drone can be traced back to 'antiquity or even prehistoric times', this might be recognised as the 'official' signposting of a general historical shift from dimensional combination two (X/Z/T) to three (X/Y/Z/T).

The practice of organum would evolve through a series of stages until the thirteenth century: the earliest forms of organum are documented by '*Musica Enchiridias*' (pp. 39) and later by Guido of Arezzo's '*Micrologus* (ca.1025-28)' (pp. 86); 'note-against-note organum' (pp. 88) is documented by '*Ad organum faciendum* (On Making Organum, ca.1100)'; Aquitanian polyphony (early twelfth century) is preserved primarily in music manuscripts; and the two leading figures of Notre Dame Polyphony (late twelfth and early thirteenth centuries), Leoninus and Perotinus, are well-documented in the treatise 'Anonymous IV' (pp. 93) written in 'about 1285'.

In all stages of its evolution, organum is characterised by a respect towards Pythagoras' concordant intervals (fifths, fourths, and unisons / octaves), particularly at points of resolution. However, the hold of these intervals was weakened with each evolutionary stage. In the Notre Dame style, for example, there is an inclination towards third and sixth intervals. Influenced by the French, the English would go further by using these intervals as consonances, as documented by Gerald of Wales in 'about 1200' (pp. 107). The emphasis on these intervals foreshadows the arrival of triadic harmony, the phasing in of the tonal system, and the subsequent phasing out of modality.

The later stages of organum are not the first evidence of denouncing the modes. In the use of the church modes, for example, it was common for the note B of 'modes 1, 2, 4, 5, and 6' (Burkholder et al., 2014, pp. 41) to be replaced with Bb. The effect of this change on mode 1

(Dorian), which had the final D, would be a conversion to the Aeolian mode. Likewise, the effect for mode 5 (Lydian), which had the final F, would be a conversion to the Ionian mode.

Because the Ionian and Aeolian modes represent the major and natural minor scales, respectively, it can be understood that the seeds of tonal dominion were begun to be sewn prior to the thirds and sixths of the Notre Dame and English styles of organum. Later, in the fourteenth through sixteenth centuries, a similar seed known as musica ficta ("feigned music") would be sewn. This involved semi-tone adjustments of scale degrees to enable smoother (more tonal) cadences, thereby undermining the purity of a mode.

The third and sixth intervals became more prominent in the fourteenth century through the French Ars Nova style, best demonstrated in the music of Guillaume de Machaut (ca.1300-1377), and the Italian Trecento music, as in the works of Francesco Landini (ca.1325-1397). In both traditions, these intervals still required resolutions to the stronger Pythagorean consonances. Moving into the Renaissance, however, the third and sixths joined the consonances and no longer required resolutions, as documented by Johannes Tinctoris' '*Liber de arte contrapuncti* (A Book on the Art of Counterpoint, 1477)' (pp. 154).

A concurrent change in harmonic approach was recorded by theorist Pietro Aaron's '*Toscanello in musica* (Venice 1524)' (pp. 156), which states that composers began to consider the individual contrapuntal lines 'all together'. In other words, harmony eased away from being a coincidence of multiple super-imposed X axis lines and drew closer to the Y axis phenomenon it is generally understood as today. These changes in the harmonic conception are clear in a type of improvised English polyphony called faburden, evidenced in the music of John Dunstable (ca.1390-1453), which inspired a similar French technique known as fauxbordon, demonstrated in the work of Guillaume Du Fay (ca.1397-1474).

The new harmonic consonances posed challenges to the existing systems of tuning. In Pythagorean intonation ('the tuning system used throughout the Middle Ages' (pp. 157)), the thirds and sixths have dissonant, complex ratios e.g., the major third ratio is 81:64. Just intonation, on the other hand, 'which performers had probably been using forms of […] for many years', makes these intervals consonant by simplifying their ratios (e.g., major third = 5:4) at the expense of de-tuning other intervals.

The common solution was to use compromise tuning systems called temperaments. Mean-tone temperament, which compromises the fifths to improve the thirds, was first adopted by keyboard players in the sixteenth century and would continue to be used in different forms alongside other modified temperaments 'through the late nineteenth century' (pp. 158).

Equal temperament, in which the semi-tones are spaced evenly and was 'first described by theorists in the late 1500s', is the tuning system that is most used today – although many exist. In the interests of being widely accessible, the 'neutral level' (Nattiez, 1990, pp. 12) model of Gravitonicity produced in Chapter 3 will be based on equal-temperament. However, it will become clear that the principles are applicable to any tuning system.

The Renaissance was also a time of renewed interest in Greek theory. Franchino Gaffurio (1451-1522), for example, 'revived the Greek names' (Nettles and Graf, 1997, pp. 12) of the modes in his '"Practica musice" (Milan, 1496)'. In the '*Dodekachordon* (The Twelve-String Lyre, 1547)' (Burkholder et al., 2014, pp. 159), Heinrich Glareanus (1488-1563) introduced the Aeolian and Ionian modes with the finals on A and C, respectively, forming the basis of relative major-minor harmony; reflecting an increasing awareness of tonality.

According to *The Chord Scale Theory & Jazz Harmony* (Nettles and Graf, 1997), a text which will play a valuable role in this research, 'the essential concept of modal scales and their names used today traces back to Glarean' (pp. 12). Lastly, Gioseffo Zarlino's '"*Le Institutioni Harmoniche*" (Venice, 1558)' (Nettles and Graf, 1997, pp. 12) would discuss the differences between the 'modern modes' and the Greek modes in how the former 'rely only on melodic and harmonic factors' and not cultural, geographic, affective qualities etc.

Zarlino’s work also ‘classified all chords as major and minor’ (pp. 14), thus laying the foundations of triadic harmony.

In addition to the new consonances, throughout the Renaissance there emerged a more sophisticated attitude towards dissonance and its potential expressive qualities. This can be traced through: the application of suspensions by the Franco-Flemish composers (1450-1520) and their more frequent but discreet use by Giovanni Pierluigi da Palestrina (1525/1526-1594); the use of direct chromatic motion (not seen since the music of Ancient Greece) in the Italian madrigals of Cipriano de Rore (1516-1565) and Nicola Vincentino (1511-ca.1576); and the unprepared and traditionally incorrectly resolved dissonances in the ‘seconda practica’ (Burkholder et al., 2014, pp. 298) of Claudio Monteverdi (1567-1643).

The harmony of the Baroque period is distinguished from that of the Renaissance by the rise of a Y axis-oriented, chord-based approach. In particular, the change was marked by a new harmonic interdependency where each Y axis structure belongs to a clear harmonic succession – something that was previously only manifested in cadences.

This new harmonic conception is evidenced by a notation system called thoroughbass, in which the melody and bass parts are composed whilst the inner voices are provided by an accompanist’s interpretation of chord symbols (known as figured bass). According to *A History of Western Music*, ‘musicians in the early seventeenth century’ (pp. 306) still considered themselves to be composing modal music, but music being written ‘by the last third of the century’ was clearly tonal. The modes became ‘subordinated to the imperial power of the tonal system’ (Vieru, 1993, pp. 16).

Like modality, the evolution of the tonal system would be gradual. Three of the key composers responsible for its initial development include: Jean-Baptiste Lully (1632-1687), whose cadential evasions depend ‘on the listener’s expectations for tonal music’ (Burkholder et al., 2014, pp. 361); Alessandro Scarlatti (1685-1757), who integrated chromaticism and diminished seventh chords into the tonal system; and Arcangelo Corelli (1653-1713) who used suspensions, secondary dominants, diminished sevenths and Neapolitan sixth chords, and the later-standardised modulations to the relative major / minor and dominant keys.

Corelli's broad tonal language was used in Jean-Philippe Rameau's landmark publication '*Traité de l'harmonie* (Treatise on Harmony, 1722)' (pp. 425) which 'founded the theory of tonal music'. Amongst other significant contributions, Rameau's treatise introduced the labels of tonic, dominant, and subdominant. Later, in *Harmony Simplified or the Theory of the Tonal Functions of Chords* (1893), the renowned theorist Hugo Riemann would develop Rameau's ideas and designate these labels as 'function(s)', having 'borrowed the word from mathematics' (Hyer, 2002, pp. 736).

It was stated at the beginning of this section that Gravitonicity is an inherent part of all music in which pitch has a discernible presence. Whilst this is true, it will be shown that it operates through functionality and can thus be limited when analysing music which overtly denies functional categorisation. The concept of functional harmony is neatly summarised in the following passage from *The Chord Scale Theory & Jazz Harmony* (Nettles and Graf, 1997, pp. 30):

> Every chord has a function or tonal responsibility. When we hear a chord progression we match each chord sound to a function. How is the chord working to make the music progress forward? Our subconscious instantly justifies the chord's function as it passes our mind's ear even if it is a chord one had previously not expected to hear. Perception of function occurs in a split second. The more experienced the listener, the better the understanding of how each event relates to the total picture.

Post-Rameau's treatise, the tonal system was 'completely crystallized' (Vieru, 1993, pp. 16) in the works of J.S. Bach (1680-1750): 'the peak from which one can look down on the past of European music, but also on its future'. *The Well-Tempered Clavier, BWV 846-893* (1722 and 1742), for example, demonstrated the complete freedom of modulation (enabled by the tempered tuning systems) to all twenty-four major and minor keys.

Bach's harmonic language represents a tonal line in the sand that would persist throughout the Classic period and only begin to be caught by the tide in the Romantic foreshadowing of Joseph Haydn's late works. For example, *A History of Western Music* (Burkholder et al., 2014) highlights 'the six quartets of Op. 76 (ca.1796-97)' (pp. 535) and cites Haydn's use of 'chromatic progressions, chromatic chords, enharmonic changes, and fanciful tonal shifts'.

The tonal system was increasingly challenged and exerted to its limits by the harmonic pioneers of the Romantic period: the music of Franz Schubert (1797-1828) shows a proclivity for tonic major / minor key relationships and modulation by a third instead of a fifth; Fryderyk Chopin (1810-1849) regularly used harmonies with 'nonfunctional relationships' (Nettles and Graf, 1997, pp. 162) and chromaticism; Franz Liszt (1811-1886) utilised symmetrical divisions of the octave such as the whole-tone and octatonic scales, and the third intervals in diminished seventh chords and augmented triads; and Richard Wagner (1813-1883) exploited the outer reaches of tonality with denied resolutions, resolutions to dissonances, chromatic alterations, and restless key changes.

Anatol Vieru writes that 'When any sound could be included in any tonality, the tonal system was, logically speaking, "consumed"' (1993, pp. 16). This did not mean its 'putting out of use', but rather the supplanting of its 'imperial role' by a bifurcation into two harmonic approaches which continue alongside tonality to the present: (1) atonality and the later twelve-tone technique (dodecaphony), and (2) a reawakened interest in modality which is labelled by Vieru as 'the new modalism'.

The seeds of the former are evident in the harmony of late Romanticism, would germinate when Arnold Schoenberg (1874-1951) began to compose the first atonal pieces in 1908, and flourished with Schoenberg's invention and application of the twelve-tone technique in the 1920s. The twelve-tone technique has a lineage through Schoenberg's students Alban Berg (1885-1935) and Anton Webern (1883-1945), and would later give rise to total/integral serialism in the works of Milton Babbitt (1916-2011), Karlheinz Stockhausen (1928-2007), and Pierre Boulez (1925-2016).

As noted above, Gravitonicity operates through functionality. An example in Chapter 3 will illustrate that, whilst functionality can be found to varying degrees in atonal, twelve-tone, and serial music, the tendency of these styles to deny functional categorisation means that Gravitonicity's role may be severely limited.

The second branch of the bifurcation, 'the new modalism' (Vieru, 1993, pp. 16), also emerged in the latter half of the Romantic period. It can be traced through composers (to name only a few) such as Modest Mussorgsky (1839-1881), Nikolay Rimsky-Korsakov (1844-1908), Claude Debussy (1862-1918), Alexander Scriabin (1872-1915), and Olivier Messiaen (1908-1992), and became foregrounded in jazz through the release of Miles Davis' *Kind of Blue* (1959a).

Unlike the atonality / twelve-tone / serialism branch, 'the new modalism' has not witnessed a Schoenbergian figure or clear lineage and was only theoretically explored in the late twentieth century by Vieru's *The Book of Modes* (1993). Whilst this neglect can be attributed to the historic dominion of tonality, Vieru alludes to another reason in terms of 'modal density' (pp. 50). He considers the twelve-tone method as a mode that is 'condemned to density 12' (pp. 17) (e.g., containing all notes of the chromatic scale) and, because of this, 'the premises and theoretical conclusions were obvious from the beginning'.

If the twelve-tone method is considered as a single mode of 'the new modalism' (pp. 16), then all the remaining densities (number of pitch classes) – and the vast number of pitch collections and modal permutations for each – remains particularly fertile ground. Moreover, each of these modes can be combined successively to create new functional relationships. This is an area where the findings of Gravitonicity could potentially offer clues to the future evolutionary stages of harmony.

Chapter 3 will contextualise the twelve-bar blues as one such type of functional relationship. Whilst the I, IV, and V chords in twelve-bar have a connection with tonality (particularly the perfect cadence from V to I), it will become clear that the dominant seventh chords built on these scale degrees correspond to perceptual events that are fundamentally separate from tonality.

Chapter 2: Literature Review

Because it is being argued that Gravitonicity is an innate property of music, it might be expected that the literature dates to the earliest writings on music theory. Moreover, as a (yet) unsystematised property, it might also be expected that the literature has little consistency in approach and can thus be difficult to trace. Both potential expectations are the case. Fortunately, however, Lee Rothfarb's *Energetics* (2002) offers an effective (if partial) historiography.

2.1: *Energetics* (Rothfarb, 2002)

Rothfarb's discussion centres around the problem of motion in music: 'what moves in music?' and 'what constitutes movement in music?' (pp. 928). 'In a melody', he writes, 'a tone of some frequency is replaced by a new one of a different frequency' as 'two distinct tones (pitch plateaus)' without 'continuous transition' (pp. 929). This line of thought may be challenged by the less-distinguishable pitch content of spectral and electroacoustic music.

Nevertheless, Rothfarb points to an 'impelling force […] that induces the changes perceived as musical motion' (pp. 929) and proceeds to assemble a historical chronology of theorists who have identified and described the 'impelling force'. Testament to the innateness of Gravitonicity, Rothfarb traces the 'impelling force' of motion to Ancient Greece in the writings of Aristoxenus (1990, pp. 180 – first documented ca.330 BCE):

> in respect of the magnitude of intervals and the pitches of notes, the facts about melody seem to be in some ways indeterminate, but in respect of functions (*dynameis*), forms and positions they appear to be determinate and ordered.

Rothfarb highlights that Aristoxenus uses '*dynameis*' to refer to the 'unique functional quality of notes […] determined by their position within the tetrachord' (2002, pp. 930). This idea remains pertinent in the modern Western understanding of harmony e.g., functionality (as discussed in section '1.2: The Evolution of Harmony in Western Music'), suspensions, chromaticism etc.

Progressing from Aristoxenus, Rothfarb identifies the 'impelling force' (pp. 929) of motion in: the part-movement of the Middle Ages, where a 'dynamic impulse' (pp. 932) is manifested by imperfect intervals resolving to more perfect concords; a 'commonly invoked' metaphor of oration throughout the Baroque era; and Adolf Bernhard Marx's (1795-1866) 'organicist view of musical form' (Rothfarb, pp. 933), which used a metaphor of 'germination and growth across the piece'.

These are followed by three harmony treatises from the eighteenth and early nineteenth centuries, including: the first use of the gravitation metaphor to describe harmony by Jean-Philippe Rameau in *Génération harmonique* (1737) ('the symmetry of a dominant and subdominant around the tonic creates a force that draws chord progressions towards a center of gravity' (Rothfarb, pp. 934)); François-Joseph Fétis' (1784-1871) 'theory of energy-laden tones operating in a dynamic force field' (Rothfarb, pp. 934); and Albert-Joseph Vivier's (1816-1903) perspective that 'the tonic is the only truly reposeful chord; all others are in motion towards the tonic' (Rothfarb, pp. 935). Following these treatises, Rothfarb identifies the ‘impelling force’ (pp. 29) in Hugo Riemann’s (1849-1919) ‘theory of musical dynamics and agogics’ (Rothfarb, pp. 935) as a ‘pervasive musical life-force (Lebenskraft)’.

The title of Rothfarb’s article, *Energetics*, ‘was first coined in 1934 by an historian of aesthetics, Rudolf Schäfke, who proposed it as a way of characterizing the work of several theorists active in the early twentieth century’ (pp. 927). Although discourse on the ‘impelling force’ (pp. 929) has a history dating back to the Greeks, it was only with ‘the energeticist school’ (pp. 936) that it became common. Rothfarb groups the first two energeticist writers, August Halm (1869-1929) and Heinrich Schenker (1868-1935), because of their shared belief that ‘the intrinsic logic of tonality and the raw musical forces governed by it were universally valid and timeless’ (Rothfarb, pp. 938).

Quoting Halm with original translations, Rothfarb writes that ‘the major third is the “impelling force’ (pp. 937), ‘dominant-tonic progressions […] possess their own “energy”’, and that ‘the key to understanding music is a “knowledge of musical processes, of the function of musical forces as they operate in chords and chord progressions, in forms”’. Schenker, on the other hand, is responsible for the most widely known account of the ‘impelling force’. This has been perpetuated through ‘textbooks, courses, seminars, and conferences on Schenkerian theory; the establishment of major research archives based round his private papers; and a seemingly endless supply of voice-leading graphs in journals and books’ (Drabkin, 2002, pp. 835).

In *Free Composition* (1979 – originally published as *Der freie Satz* in 1935), Schenker writes that form is ‘an energy transformation […] of the forces which flow from the background to the foreground through the structural levels’ (pp. 162) and that ‘all growth […] finds its fulfillment only through the control of the fundamental structure (Ursatz) and its transformations’ (pp. 18). In other words, the Ursatz (I – V – I) represents three energetic / gravitational extremities in the ‘background (*Hintergrund*)’ (Drabkin, 2002, pp. 819) and elaborations of the ‘energy transformation’ (Schenker, 1979, pp. 162) are housed in the ‘middleground (*Mittelgrund*)’ (Drabkin, 2002, pp. 819) and more-so in the ‘foreground […] (*Vordergrund*)’.

Ernst Kurth (1886-1946) ‘arguably articulated the most comprehensive and thorough-going theory of energetics’ (Rothfarb, 2002, pp. 936). For Kurth, ‘melody occurs between the tones, in the sweep of kinetic energy that flows through them and becomes dammed up, as potential energy, in chords’ (pp. 940). Similarly to Rameau, Kurth used the gravitation metaphor to characterise an ‘attraction between tones’ (pp. 941) which results in ‘“cohesion” among energy-laden tones momentarily “caught” in chords’ and, in ‘the stepwise continuation of a chordal dissonance’, a ‘release (*Auslösung*) of constrained forces’.

Perhaps the most significant of Kurth’s contributions, however, was locating the ‘impelling force’ (pp. 929) in the ‘esthesic dimension’ (Nattiez, 1990, pp. 12). Whereas the attention of earlier writers was on the ‘neutral level’ (e.g., the musical text), Kurth identified that: ‘“Music is a natural force within us, a dynamic of volitional impulses . . . Sound is dead.’ (Rothfarb, 2002, pp. 941); ‘“Every sonority is merely an aurally grasped image of certain energetic tendencies”’; and, fundamentally, ‘Musical activity merely expresses itself in tones, but it does not reside in them.’ (pp. 948).

Like Kurth, the three remaining writers of ‘the energeticist school’ (pp. 929) primarily attended to the ‘esthesic dimension’ (Nattiez, 1990, pp. 12). Arnold Schering (1877-1941) posited that ‘all musical activity boils down to the “operation of the basic psychological law of tension and release,”’. Hans Mersmann (1891-1971) was ‘one of the first music theorists to attempt a phenomenology of music’ (Rothfarb, pp. 946), arguing that ‘“The fundamental phenomena of an art work […] are based on a continual succession of tension and release phases’ (pp. 947). Lastly, for Kurt Westphal (1904-1978), ‘form […] cannot be read from the anatomical structure of the work’ (Rothfarb, pp. 948) – the ‘neutral level’ (Nattiez, 1990, pp. 12) – ‘Rather, it acquires its reality in the aural process, a reality which is therefore a purely psychic one’ (Rothfarb, 2002, pp. 948).

Rothfarb's article is concluded with a section titled 'Late twentieth-century reverberations' in which he identifies a continuation of energeticist thinking on the 'esthesic dimension' (Nattiez, 1990, pp. 12) in the works of Wallace Berry and Victor Zuckerkandl. In *Structural Functions in Music* (1987 – originally published in 1976), Berry argues that 'intensities develop and decline, and […] analogous feeling is induced' (pp. 4) as 'meaning' (pp. 1) according to 'change in one or more musical parameters (pitch, harmony, key, rhythm, texture, etc.)' (Rothfarb, 2002, pp. 950).

For Zuckerkandl, tones are 'dynamic symbols' (1956, pp. 69). This idea advances the understanding of Gravitonicity's 'esthesic dimension' (Nattiez, 1990, pp. 12) from the lens of 'neutral level' analysis to semiotic inquiry. Semiotics is the study of signs. In the posthumously published *Course in General Linguistics* (1983 – originally published in 1916), Ferdinand de Saussure founded a tradition of semiotics known as semiology. Saussure claimed that 'the linguistic sign consists of two elements, the *signifier* (the actual phonetic sound) and the object to which it refers, which he called the *signified*' (Beard and Gloag, 2005, pp. 168).

In *Music and Cultural Theory* (1997), John Shepherd and Peter Wicke produce a 'Semiological model' (pp. 173) of music. Their work provides a comprehensive account of how 'sound in music functions in a manner distinct from sound in language' yet is 'as fundamental as language to the formation and persistence of human societies' (pp. 3). The different signification processes lead the authors to cast the 'sonic saddle' (pp. 159) – a term borrowed from Zuckerkandl (1956, pp. 227) – in place of the signifier, and 'elements of signification'' to 'subsume the concept of the signified' (Shepherd and Wicke, 1997, pp. 170). Shepherd and Wicke's 'Semiological model' (pp. 173) will receive greater attention in Chapter 3 as the key to extrapolating the 'esthesic dimension' (Nattiez, 1990, pp. 12) of Gravitonicity i.e., how pitch content can have alternate meanings to 'different individuals' (Shepherd and Wicke, 1997, pp. 175) and 'the same individual at different times'.

To fully understand how the 'esthesic dimension' brings meaning to the 'neutral level' of Gravitonicity, the latter must first be modelled. In a similar but more explicit description than Fétis' 'theory of energy-laden tones operating in a dynamic force field' (Rothfarb, pp. 934), Zuckerkandl argues that 'Motion […] always implies something that does not move or that moves differently – a frame, a background, against which the motion appears as motion' (1956, pp. 95). This distinction between 'motion' and 'a frame' is of the utmost importance. To understand how the 'motion appears as motion', there must first be an appreciation and formulation of the field it inhabits.

Although Rothfarb's article focuses on the 'impelling force […] that induces the changes perceived as musical motion' (2002, pp. 929), his chronology demonstrates surprisingly little historical attention to the 'dynamic force field' (pp. 934) or 'frame' (Zuckerkandl, 1956, pp. 95). Rothfarb writes that 'the twentieth-century energeticists […] do not attempt to concretize their psychological speculations, or to quantify their analytical findings about the details of music's dynamic properties or about the contours of a work as a whole' (2002, pp. 948). These 'tasks', he continues, 'have fallen to more modern-day authors, music theorists and psychologists' (pp. 949). Because this thesis aims to model Gravitonicity, these are the contributions that this literature review will focus on.

2.2: The Harmonic Series and Distance

In his *Theory of Harmony* (1978 – originally published in 1911), Arnold Schoenberg argues that a single tone (C) can be 'taken as the midpoint' with 'reference to two forces, one of which pulls downward, toward F, the other upward, toward G' (pp. 23). Then, by treating each tone as the fundamental of its own harmonic series, he finds that their most 'closely related' (pp. 24) harmonics / 'nearest relatives' collectively form a C major scale.

The distance metaphor evoked by ‘nearest relatives’, ‘closely related’, and (elsewhere) ‘more distant’, suggests that Schoenberg conceived of the major scale as a ‘field’ (Rothfarb, 2002, pp. 934) or ‘frame’ (Zuckerkandl, 1956, pp. 95). If it is possible to conceive of the major scale as a distance framework through the harmonic series, it follows logically that it can be joined by other scales, modes, and chords. However, the historical evolution of harmony was different to that offered by the natural blueprint of the harmonic series. As Schoenberg writes:

> To explain the constitution of the major triads we may cite the prototype in the overtone series. Even if we accept, however, the inversion of the idea of the triad and the undertones as an explanation of the minor triads, all such reasoning becomes inapplicable when we think of diminished and augmented triads and sevenths chords, all such combinations that are [nevertheless] recognized as chords. These and the triads that are [satisfactorily] explained have nothing more in common than the superimposed thirds of their structure; and such is surely inadequate [as explanation]. (1978, pp. 312)

History ‘tells only in what order and by what route those harmonies broke into music’ (pp. 315) with no ‘unambiguous explanation’ (pp. 314) for how they did so. Schoenberg postulates that these structures may have emerged from part-writing, as natural creations of the human mind, and/or from continued tonal and functionally independent usage that has conditioned our ears. Whatever the reason(s) for our acceptance of these structures, Schoenberg recognises the introduction of tempered tuning systems as when ‘the burning urgency to search’ the harmonic series was ‘tempered’. However, as will be argued in the coming pages, the search for meaning continued (and continues) in the spectra of the tones played.

Perhaps inspired by Schoenberg's conception of the major scale as a distance framework, Paul Hindemith undertakes a more extensive analysis of the harmonic series in *The Craft of Musical Composition* (1941). The product of the analysis is a 'ranking' (pp. 54) of 'the twelve tones of the chromatic scale' (pp. 56) by a 'diminishing degree of relationship' to a single 'progenitor tone' (pp. 54) / 'sun' (pp. 57) / 'central star': 'Series 1' (pp. 56). This is shown in Example 2.2a with C as the 'progenitor tone' and the 'degree of relationship' increasingly 'diminishing' towards the right e.g., G is closer to C than F, A is more distant than F, then E etc.

C	G	F	A	E	Eb	Ab	D	Bb	Db	B	Gb/F#

Example 2.2a: Hindemith's 'Series 1' (1941, pp. 56): a 'ranking' (pp. 54) of 'the twelve tones of the chromatic scale' (pp. 56) by a 'diminishing degree of relationship' to a single 'progenitor tone' (pp. 54).

Hindemith derives 'Series 1' from several calculations. Beginning with a fundamental (C / 64Hz), he treats the second harmonic of the series (C / 128Hz) as the 'upper limit' (pp. 33) and sets about populating the octave with the remaining eleven tones. He identifies G as the third harmonic of the series and divides the frequency by two to fit it in the desired octave e.g., 192Hz / 2 = 96Hz. To derive F, Hindemith takes the fourth harmonic of the series (C) and divides it by three e.g., 256Hz / 3 = 85.33Hz. Because G is derived from the third harmonic whereas F is derived from the fourth, Hindemith deems G to have a closer relationship to the fundamental / ‘progenitor tone’ (pp. 54).

The tones Hindemith deems to have a weaker relationship to the ‘progenitor tone’ occur later in the harmonic series of the fundamental and are also derived from the harmonics of harmonics. For example, the frequency of D may be derived by: (1) dividing the ninth harmonic of the fundamental by eight (576Hz / 8 = 72Hz), or (2) by dividing the third overtone of G (96Hz, as derived from the ‘progenitor tone’) by four (288Hz / 4 = 72Hz). Because of the calculated frequencies, a by-product of ‘Series 1’ is an original tuning system. However, the proposed applicability to equal temperament is emphasised by Hindemith’s inclusion of both tuning systems in the graphic representation of ‘Series 1’ (pp. 56) in the text.

According to Hindemith, ‘Series 1’ is ‘valid under all circumstances’ (pp. 54). However, there is varying correlation between ‘Series 1’ (pp. 56) and common / tonal configurations of pitches. For example, whilst the first five tones of the order belong to a C major scale, both Eb and Ab precede D (second scale degree), and Bb and Db (including the preceding tones) precede B (seventh scale degree). Despite this and other notable exceptions, there may exist a ‘natural’ (pp. 55), omni-present order derived from the spectra of the single tone – even if correlation with all configurations of tones is an impossibility.

Like Schoenberg’s treatment of tones as ‘relatives’ (1978, pp. 24), Hindemith’s ‘degree of relationship’ (1941, pp. 56) evokes the distance metaphor. Moreover, although Hindemith does not explicitly reference other literature, he suggests that this was not a new or uncommon way of thinking about music:

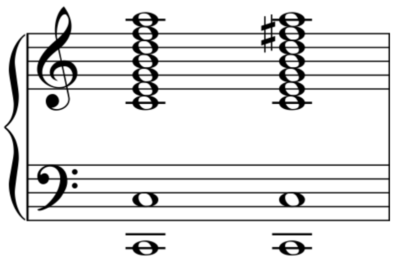
> All theorists are agreed, it is true, that there are various degrees of relationship, and the order of descending degrees of relationship is the same in all theories. This is remarkable, for in every other respect there is anything but unanimity among musical theorists. It seems as if a true feeling for the relationships had existed even without the only complete explanation of them, here given for the first time. (pp. 55)

The third and final figure in the lineage of deriving ‘distance’ from the harmonic series is George Russell. *The Lydian Chromatic Concept of Tonal Organization: The Art and Science of Tonal Gravity* (2001), originally published in 1953 as *The Lydian Chromatic Concept of Tonal Organization for Improvisation*, is one of the most extensive self-contained accounts of the ‘frame’ (Zuckerkandl, 1956, pp. 95) that the motion may inhabit. According to Russell, the stimulus to develop the theory was a conversation with Miles Davis in 1945:

> I asked, “Miles, what's your musical aim?” His answer, “to learn all the changes (chords),” was somewhat puzzling to me since I felt- and I was hardly alone in the feeling- that Miles played like he already knew all the chords. After dwelling on his statement for some months, I became mindful that Miles' answer may have implied the need to relate to chords in a new way. (2001, pp. 10)

The theory (hereby the LCC) is built on the fact that the fifth is the first interval to follow the initial octave in the harmonic series. Consequently, Russell determines that the fifth is ‘the strongest harmonic interval’ (pp. 3) and ‘the most scientifically sound basis upon which to structure an objective theory of music'. The text then states that the Lydian mode, as 'a ladder of fifths' (C Lydian = C-G-D-A-E-B-F#), is 'the natural child of the overtone series'.

In support of this claim, Russell compares the tertian order of the major scale (Ionian) and the Lydian mode – as shown in Example 2.2b. According to Russell, the Lydian tertian structure (right) 'sounds a greater degree of unity and finality with its tonical C major triad' (pp. 1). This can be explained by the dissonance of the minor ninth interval between E and F in the Ionian structure (left). Russell also points out that the eleventh overtone of the harmonic series (fundamental C) has a logarithm frequency of 551 cents, making it closer to Lydian's F# (600 cents) than Ionian's F (500 cents).



Example 2.2b: The tertian structures of Ionian (left) and Lydian (right).

Next, Russell argues that 'Tonal Gravity, or "tonal magnetism," […] flows in a downward direction' through the Lydian 'ladder of fifths', 'conferring ultimate tonical authority on its lowermost tone' and thus forming 'a self-organized GRAVITY FIELD' (pp. 3). In the same vein as Schoenberg and Hindemith, Russell adds that 'all tonal phenomena are graded on the basis of their close to distant relationship' to a 'Lydian Tonic' / '"Sun Absolute"'. For example, in C Lydian, C is the 'Lydian Tonic', G bears the closest relationship to it, and F# is the most distant. Russell proceeds to extend the Lydian mode into a twelve-tone 'Lydian

Chromatic Scale' (pp. 12). This is shown in Example 2.2c with F as the 'Lydian Tonic' (pp. 3).

F	C	G	D	A	E	B	C#	Ab	Eb	Bb	Gb
I	V	II	VI	III	VII	+IV	+V	bIII	bVII	IV	bII

Example 2.2c: Russell's 'Lydian Chromatic Scale' (2001, pp. 12): a grading of 'all tonal phenomena […] on the basis of their close to distant relationship' (pp. 3) to a 'Lydian Tonic'.

The 'Lydian Chromatic Scale' (pp. 12) is applied to any chord ('VERTICAL TONAL GRAVITY CENTERING ELEMENT' (pp. 102)) as a 'parent scale' (pp. 20), not unlike how the modes may first be learned as relatives of the major scale e.g., understanding F Lydian as a C major scale rooted on F. In Russell's work, however, all modes and their constituent chords are traced back to Lydian as the 'parent scale'. For example, in the contexts of C Ionian, D Dorian, E Phrygian, G Mixolydian, A Aeolian, or B Locrian, the 'close to distant relationship' (pp. 3) of all tones would be in accordance with their arrangement in an 'F Lydian Chromatic Scale' (pp. 12).

In theory, therefore, the 'Lydian Chromatic Scale' (pp. 12) satisfies Miles Davis' quest to 'relate to chords in a new way' (pp. 10). However, Russell argues that the 'Lydian Chromatic Scale' (pp. 12) retains the 'ladder of fifths' (pp. 3) whilst 'being in accord with the development of Western harmony' (pp. 17). The latter creates two intervallic inconsistences with the former. Firstly, the interval between the B (+IV scale degree) and C# (+V) is not a fifth, but a major second. Russell argues that this is to 'accommodate the evolution of the five main Western chord types' (pp. 53).

Secondly, there is an interval of an augmented fifth or minor sixth between Bb (IV) and Gb (bII). This is not explained in the text but is presumably to accommodate the final chromatic pitch. Would both intervals not interfere with the 'GRAVITY FIELD' (pp. 3) of the 'ladder of fifths'? Further issues with the theory have been revealed by Jeff Brent's '*Lydian Chromatic Concept' Discrepancies* (2016).

Moreover, there is no evidence to suggest that Miles Davis, the musicians he played with (John Coltrane, Bill Evans, John Scofield etc.,), or his inspired descendants (most jazz musicians) have applied Russell's conception of 'Tonal gravity' (Russell, 2001, pp. 3). Focused studies of the LCC's influence, such as Peter Burt on Toru Takemitsu (2002) and Brett Clement on Frank Zappa (2014), reveal arguable harmonic influence but no evidence of applying the 'gravity' concept.

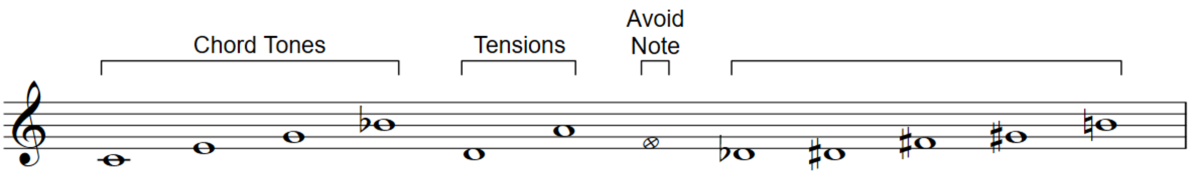
Despite this, the LCC has survived with a certain mystique amongst curious jazz musicians which, in part, may be accredited to its general inaccessibility (dense prose, pseudo-scientific language, and price point). Nevertheless, it may also be attributed to a general awareness of and belief in the 'close to distant relationship' (Russell, 2001, pp. 3) amongst the pitches.

The LCC is also attractive for the creative and analytical prospects of understanding the 'close to distant relationship' of all twelve pitch classes in any harmonic context. The emancipation of all pitch classes has clear parallels with the twelve-tone techniques of Arnold Schoenberg and the later serial composers, Nicolas Slonimsky's *Thesaurus of Scales and Melodic Patterns* (1947), and 'playing out' in jazz improvisation (e.g., Dean-Lewis, 2001). However, whereas the pitch collections generated by such methods may be arbitrary or the result of a calculation, the LCC seemingly offers the integration of all twelve pitches into functional harmony via their twelve-point distance ranking. Bringing a solution this problem is the main goal of this work's 'neutral level' (Nattiez, 1990, pp. 12) model.

2.3: The Chord Scale Theory and Spectral Analysis

An important tool used to achieve this goal is 'Chord Scale Theory' (hereby CST). CST is standard tuition at Berklee College of Music and can be found most comprehensively realised in Barrie Nettles' and Richard Graf's *The Chord Scale Theory & Jazz Harmony* (1997). Although some scholars (Larson, 2012, pp. 117; McClimon, 2016, pp. 99) believe CST's origins lie in George Russell's descriptions of 'indestructible chord/scale unity' (2001, pp. 10), Andrew J Pokorny (2014, pp. 17) convincingly traces it back to earlier work by Joseph Schillinger (1940; 1946).

CST is comprised of 'chord scales' (Nettles and Graf, 1997, pp. 17) and how they relate by 'function' (pp. 30 – as cited in section '1.2: The Evolution of Harmony in Western Music') to the various harmonic contexts of tonality, modality, blues, and so-called 'nonfunctional relationships' (pp. 162). The chord scales are scales and/or modes for which the constituent tones are organised into 'three qualities' (pp. 17): 'Chord Tones', 'Tensions', and 'Avoid Notes'. Example 2.3a shows a C Mixolydian chord scale for which the 'Chord Tones' form a dominant seventh chord (C-E-G-Bb), the 'Tensions' are the second/ninth (D) and sixth/thirteenth (A), and the only 'Avoid Note' is the fourth/eleventh (F).



Example 2.3a: The 'three qualities' (Nettles and Graf, 1997, pp. 17) of a C Mixolydian chord scale.

CST will be one of the foundation-stones of the methodology (Chapter 3). It will be explained that the three qualities (in the order given above) represent ‘nearest relatives’ to ‘more distant’ (Schoenberg, 1978, pp. 24), a ‘diminishing degree of relationship’ (Hindemith, 1941, pp. 56), or a ‘close to distant relationship’ (Russell, 2001, pp. 3). It will also be explained that the notes outside of the chord scales (e.g., those within the unlabelled bracket in Example 2.3a) represent a fourth, more distant quality.

To derive the relative distances of notes within each of the four qualities, this research will join the lineage of authors that have explored Music’s ‘gravitation’ through the harmonic series e.g., Schoenberg (1978 – originally published in 1911), Hindemith (1941), and Russell (2001 – originally published in 1953). Whereas these predecessors only had access to the harmonic series, this study has benefitted from the *TS2* (2021) software by IRCAM (Institute for Research and Coordination in Acoustics/Music).

TS2 enabled analysis of the harmonic spectra belonging to the single tone and various equally-tempered tone combinations. The findings of the spectral analysis successfully generate distance frameworks for all chord scales, demonstrate why chord scales are attributed to specific tone combinations, and bring acoustic justification to CST. The spectra of the single tone will also be examined for supporting evidence of Hindemith’s ‘Series 1’ (1941, pp. 56) and George Russell’s ‘Lydian Chromatic Scale’ (2001, pp. 3).

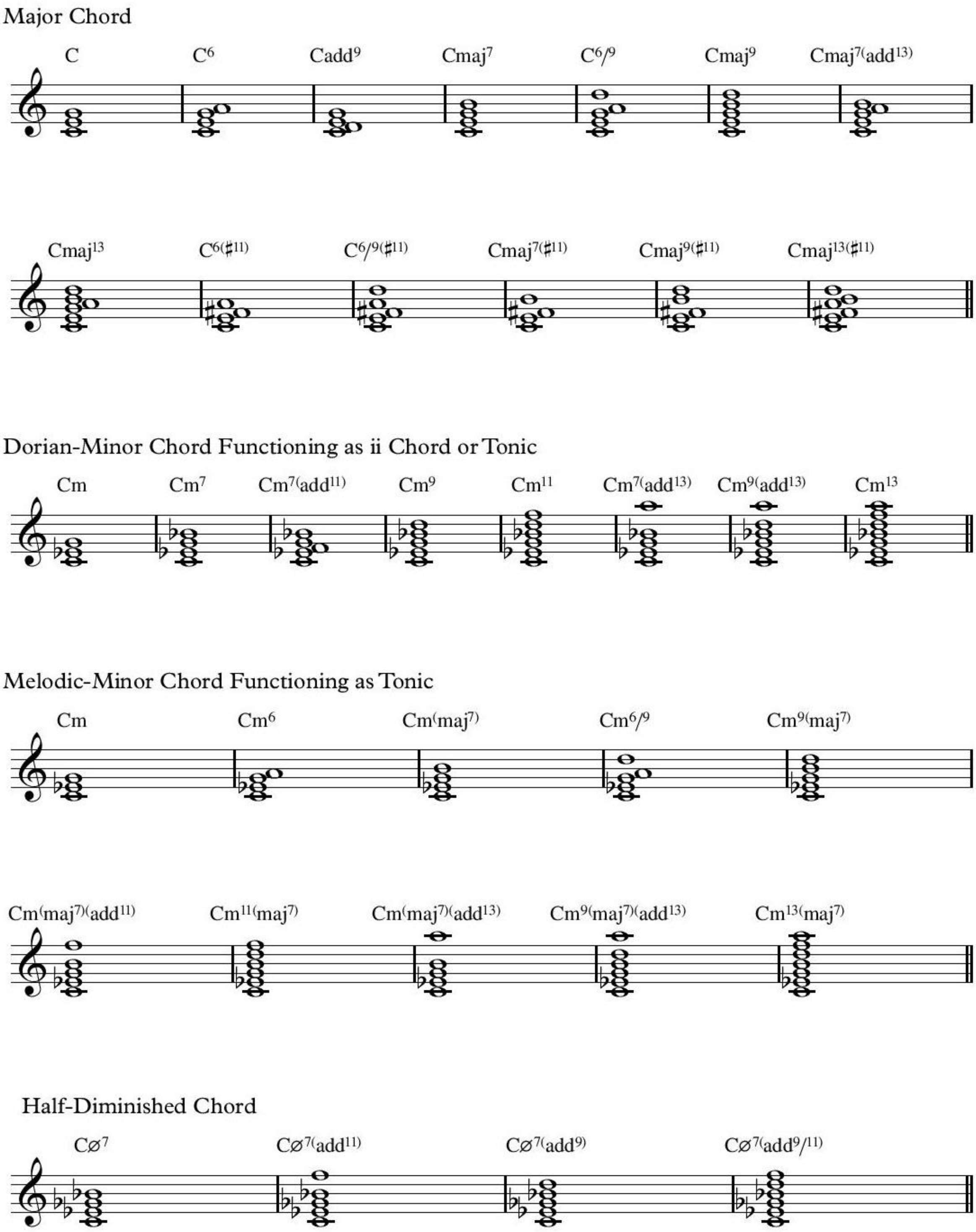
An online search will reveal that CST tends to be criticised by some practitioners. These critiques are almost unanimously rooted in how the theory – whether understood from the ground-up or mapped onto prior knowledge – does not rapidly translate into practical results. Yet, the same qualms may be had over the practical application of any theory that is yet to be used intuitively and sympathetically alongside other musical parameters. As Nettles and Graf state: ‘The knowledge about chord structures and vertical analysis is just one aspect of harmony; only a comprehensive understanding of the interrelation of chord changes and the horizontal musical flow provides a deeper appreciation of *moving* music’ (1997, pp. 7). Like

CST, the ‘neutral level’ (Nattiez, 1990, pp. 12) model theorises how we *perceive* harmony. The practitioner can determine the extent to which they may / may not use this knowledge.

Sections 2.4 to 2.6 of this Chapter will review literature that has derived distance frameworks through alternative strategies. These sections will address the extent to which alternative frameworks correlate with and potentially build upon the CST conception of distance. Examples of the latter will be highlighted and drawn upon for comparative purposes during the later spectral analysis.

2.4: Tomaro and Wilson’s Sequences

In *Instrumental Jazz Arranging* (2009), Mike Tomaro and John Wilson offer a ‘generally accepted sequence of tension and density for each chord type’ (pp. 385) that somewhat reflects the conception of chord scales as distance frameworks. They claim that ‘tension’ is increased through ‘the introduction of major and minor seconds and tritones’ and that ‘density’ is constituted through ‘the number of color tones and alterations’. These sequences and their corresponding chord types are in shown in Example 2.4a and Example 2.4 cont., with tension and density increasing throughout each sequence.



Example 2.4a: Tomaro and Wilson's 'tension and density' (2009, pp. 385) sequences for each chord type. 'Tension' and 'density' increase as each sequence progresses.

Example 2.4a cont.: Tomaro and Wilson's 'tension and density' (2009, pp. 385) sequences cont.

Perhaps confusingly, whilst ‘Tensions’ (Nettles and Graf, 1997, pp. 17) represent a more distant set of pitches than ‘Chord Tones’ in the CST distance framework, Tomaro and Wilson’s ‘tension’ (2009, pp. 385) is a property of voicing and instead ‘density’ represents the distance. This conflation of properties permeates each of the ‘tension and density’ sequences. For example, whereas CST indicates that the notes of the seventh chord are the closest, Tomaro and Wilson’s ‘Major Chord’ sequence shows the C6 and Cadd9 chords as exhibiting less tension and density than Cmaj7. Moreover, the relative distances of the $6^{th}/13^{th}$ and 9^{th} (‘Tensions’ in CST) are unclear as they are switched in and out between chords as tension and density increases.

Factors such as these will make comparisons difficult between Tomaro and Wilson’s sequences and the findings of the spectral analysis. Nevertheless, the general absence of ‘Avoid Notes’ in the sequences supports their dissonant and more distant status in CST. For example, F (11 – the ‘Avoid Note’ in Ionian) does not appear in any of the ‘Major Chord’ structures in Example 2.4a. Similarly, Db (b9 – the ‘Avoid Note’ in Locrian) does not appear in any of the ‘Half-Diminished’ structures.

The sequences also support the distant ‘fourth quality’ of CST with a complete absence of these pitches. Additionally, this illustrates that the fourth quality is beyond the scope of traditional jazz harmony.

2.5: *Tonal Pitch Space* (Lerdahl, 2001)

Fred Lerdahl’s *Tonal Pitch Space* (2001) is perhaps the most extensive and systematic distance-oriented theory. Before introducing his own work, Lerdahl undertakes a literature review of geometric models from music theory and music psychology that ‘correlate spatial distance with intuitive musical distance’ (pp. 42).

The reviewed models include (all quotations from Lerdahl): David Heinichen's (1728) 'major circle of fifths' alternating with their 'relative minor counterpart's (e.g., C-a-G-e-D-b etc); David Kellner's (1737) 'double circle of fifths', with the major keys as the outer circle and their relative minor keys as the inner circle; Gottfried Weber's (1821-1824) 'chart' in which 'The circle of fifths appears on the vertical axis, with relative and parallel major-minor relationships alternating on the horizontal axis'; a 'lattice structure' (pp. 43) 'first proposed by the mathematician L. Euler 1739', used by Hugo Riemann as the '*Tonnetz* (table of relations)', and more recently adopted by neo-Riemannian theorists; and Roger Shepard's (1982) three-dimensional 'double helix' / '"melodic map"' which consists of a circle of fifths as the base with 'two strands of whole-tone scales' (pp. 44) rising from it. More recently, geometric representations have received impressive development in the work of Dmitri Tymoczko (2011).

Lerdahl identifies and classifies three types of distance from the reviewed models that he finds none of which represent simultaneously and/or without problems: 'the relative proximity of pcs' (pp. 45) (pitch classes) 'in a tonal context'; 'the relative proximity of chords within a region' (within a key); and 'relative proximity among tonal regions' (between keys).

Setting out to fill this gap, Lerdahl posits 'The basic space' (pp. 47) shown in Example 2.5a. The five levels (a-e) represent 'the relative proximity of pcs in a tonal context' (pp. 45). Lerdahl writes that 'Level a is octave (or root) space, level b is fifth space, level c is triadic space, level d is diatonic space, and level e is chromatic space' (pp. 47) e.g., the pitch classes added at level e represent the least proximate (most distant). The 'space' of other chords in a key is modelled by adjusting levels a-c whilst maintaining the same diatonic collection in level d.

level a:	C												(C)
level b:	C							G					(C)
level c:	C				E			G					(C)
level d:	C		D		E	F		G		A		B	(C)
level e:	C	Db	D	Eb	E	F	F#	G	Ab	A	Bb	B	(C)

Example 2.5a: Lerdahl's 'the basic space' (2001, pp. 47), in which the 'relative proximity of pcs' (pp. 45) decreases with each lower level.

Lerdahl argues that 'The seventh-chord level is excluded because in Classical music seventh chords have little independent status', but if 'judged to be harmonic, it can be added at the triadic level'. This resonates with the organisation of CST. However, the initial absence of the seventh at level c suggests that it is more distant than the triad. In addition, levels b and c indicate that the third is more distant from the chord root than the fifth. This produces a distance order of (close to distant): root, fifth, third, seventh. The spectral analysis in Chapter 3 will verify this order for the major seventh chord but show that it is not applicable to all types of seventh chords.

Whereas CST offers a distinction between the 'Tensions' and 'Avoid Notes' (Nettles and Graf, 1997, pp. 17), these are both introduced at level d of Lerdahl's space (D and A are 'Tensions' and F is an 'Avoid Note'). This distinction is an important one and will be substantiated in Chapter 3.

Before discussing the second and third types of distance that Lerdahl aims to model, it is important to highlight that this research will focus on 'the relative proximity of pcs' (Lerdahl, 2001, pp. 45) distance type. Unlike Lerdahl, however, the study will not be limited to tonal contexts. The attention will be towards the frameworks, how their individual distance values are apportioned, and the largely untapped processes that lead to their attribution. It will be argued that all types of functional relationship are constructed by the sequential arrangement of these frameworks.

Despite not being the focus of this research, it is necessary to acknowledge that these frameworks may inhabit a broader space. From ‘the basic space’ (pp. 47), Lerdahl judges ‘the relative proximity of chords within a region’ (pp. 45) (key) via a two-stage process. The first stage is counting the ‘shortest number of steps’ (pp. 55) (ascending or descending) around the diatonic circle of fifths (C–G–D–A–E–B–F) between two chords roots e.g., F and G are both a single step from C.

Secondly, ‘the number of distinctive pcs’ (pitch classes) are counted at each level of ‘the basic space’ (pp. 47) between each chord. The total of the two numbers yields the distance between two chords in a single key. Example 2.5b shows the ‘chord distances’ (pp. 56) in a major key from the tonic. Lerdahl’s calculation shows that IV and V are equidistant from I, as are iii and vi, and ii and vii°.

Distance:	0	8	7	5	5	7	8
Chord:	I	ii	iii	IV	V	vi	vii°

Example 2.5b: Lerdahl’s ‘relative proximity of chords within a region’ (2001, pp. 45), i.e., ‘chord distances’ (pp. 56) from the tonic in a major key.

Finally, Lerdahl's solution for calculating 'relative proximity among tonal regions' (pp. 45) (chords in different keys) is the 'CHORD/REGION DISTANCE RULE' (pp. 70). This subsumes an extended version of 'the relative proximity of chords within a region' (pp. 45) calculation, and a 'REGIONAL DISTANCE RULE' (pp. 68) that accounts for 'regional space' (pp. 64) (represented as a 'toroidal structure') and 'tonic reorientation' through pivot chords. The full process is too extensive and algebraic to be satisfactorily summarised here. Therefore, if curious about the less immediate distance / space of Gravitonicity, the reader should go directly to Lerdahl's *Tonal Pitch Space* (2001).

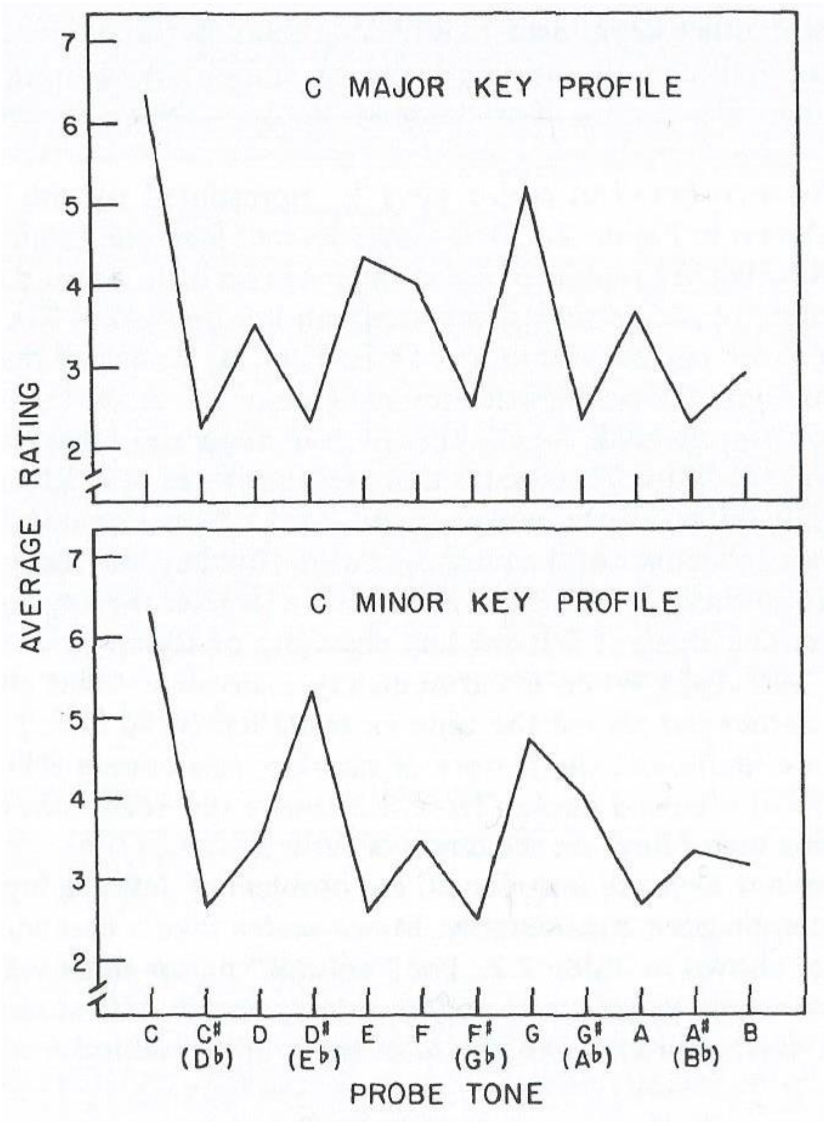
<u>2.6: Tonal Hierarchies</u>

In *Cognitive Foundations of Musical Pitch* (2001), Carol Krumhansl and associates observe the same three distance types as Lerdahl. Whereas the literature on distance reviewed thus far has focused on the 'neutral level' (Nattiez, 1990, pp. 12), Krumhansl's work approaches the 'subjective (internal) experience of music' (2001, pp. 4) – the 'esthesic dimension' (Nattiez, 1990, pp. 12) – by investigating and quantifying listener's responses to 'objective (external) music stimulus' (Krumhansl, 2001, pp. 4). These experiments offer validation for 'the part of the musical experience that can be traced quite directly to objective musical structures' (pp. 5), focusing on 'general rules governing human cognition' whilst being 'less concerned with the occasional exception or special case'.

The first of Lerdahl's distance types, 'the relative proximity of pcs' (2001, pp. 45), is reflected by the concept of the 'tonal hierarchy' (Krumhansl, 2001, pp. 18): 'an abstract, invariant hierarchy of stability' (pp. 19) that 'designates one particular tone as most central' (pp. 18) to which 'The other tones all have functions […] in terms of their relatedness'. major and minor key tonal hierarchies were generated using the ‘probe tone method’ (pp. 21) in two experiments (Krumhansl and Shepard, 1979; Krumhansl and Kessler, 1982).

The second experiment – ‘undertaken to replicate and extend the results of the first study’ (Krumhansl, 2001, pp. 25) – sounded a series of ‘context types […] in both major and minor keys’: ‘complete scales’, ‘tonic triads (the I chords)’, and ‘three different chord cadences (IV V I, VI V I, and II V I)’. Following each context, a ‘probe tone’ was sounded (‘the tones of the chromatic scale’) and the listeners’ task was to ‘rate how well the final probe tone “fit with” the context in a musical sense’ on a scale of ‘1 = “very bad” to 7 = “very good”’ (pp. 21).

Krumhansl and Kessler found that whilst the rating data ‘did not depend strongly on the particular context chosen to establish the intended key (pp. 29), ‘the results for the tonic triad chord context and the three cadence context were more similar to each other than these were to the results for the scale context’. Consequently, although Krumhansl emphasises that the differences ‘were quite minimal’, she and Kessler elected to omit the scale context from the results. Example 2.6a shows the average rating data of the chord contexts (relative to C) for both major and minor keys.



Example 2.6a: Krumhansl and Kessler's (1982) tonal hierarchies for major and minor keys, as they appear in *Cognitive Foundations of Musical Pitch* (Krumhansl, 2001, pp. 31). Participants were asked to 'rate how well' (pp. 21) each of the twelve tones fit following major and minor key contexts on a scale of '1 = "very bad" to 7 = "very good"'. The graphs show the average rating data.

Unlike the literature on distance reviewed thus far, the tonal hierarchies for the major and minor keys were generated from cognitive response to specific, real-time contextual stimuli. This leads to a conflation of the underlying distance frameworks with the 'impelling force […] that induces the changes perceived as musical motion' (Rothfarb, 2002, pp. 929), With the omitted 'scale context' (Krumhansl, 2001, pp. 29), for example, 'somewhat higher ratings were given to the scale tones near the final tonic'.

The effect on the data in Example 2.6a is identifiable from mixed correlation with the other literature. The higher ratings attributed to the tones comprising the triad in each hierarchy correlates with the organisation of CST, Tomaro and Wilson's 'tension and density' (2009, pp. 385) sequences, and Lerdahl's 'basic space' (2001, pp. 47). Furthermore, in the major key hierarchy, the fifth (G) being rated higher than the third (E) or seventh (B) correlates with levels b and c of Lerdahl's 'basic space'. Likewise, the third being rated higher than the seventh correlates with the initial absence of the latter in 'level b' of Lerdahl's 'basic space'.

Therefore, Krumhansl's major key hierarchy and Lerdahl's 'basic space' point to the same distance order amongst the notes of the major seventh chord (close to distant): root, fifth, third, seventh. As noted when discussing Lerdahl's 'basic space', the spectral analysis will verify this order for the major seventh chord but show that it is not applicable to all types of seventh chord.

The minor key tonal hierarchy is somewhat problematic because the cadence 'context types' (Krumhansl, 2005, pp. 25) included chords that are not shared by all minor scales e.g., a major V chord belongs to harmonic and melodic minor but not natural. Because of this, it is controversial whether the hierarchy should be understood to represent the minor key as a whole. It is interesting, therefore, to find A#/Bb (seventh of natural minor) rated higher than B (seventh of harmonic and melodic minor). This may be accredited to the resolution from B to C in the cadence contexts, highlighting the former as a dissonance (third of V) rather than a stable member of the harmonic / melodic minor tonic chord (e.g., C-Eb-G-B).

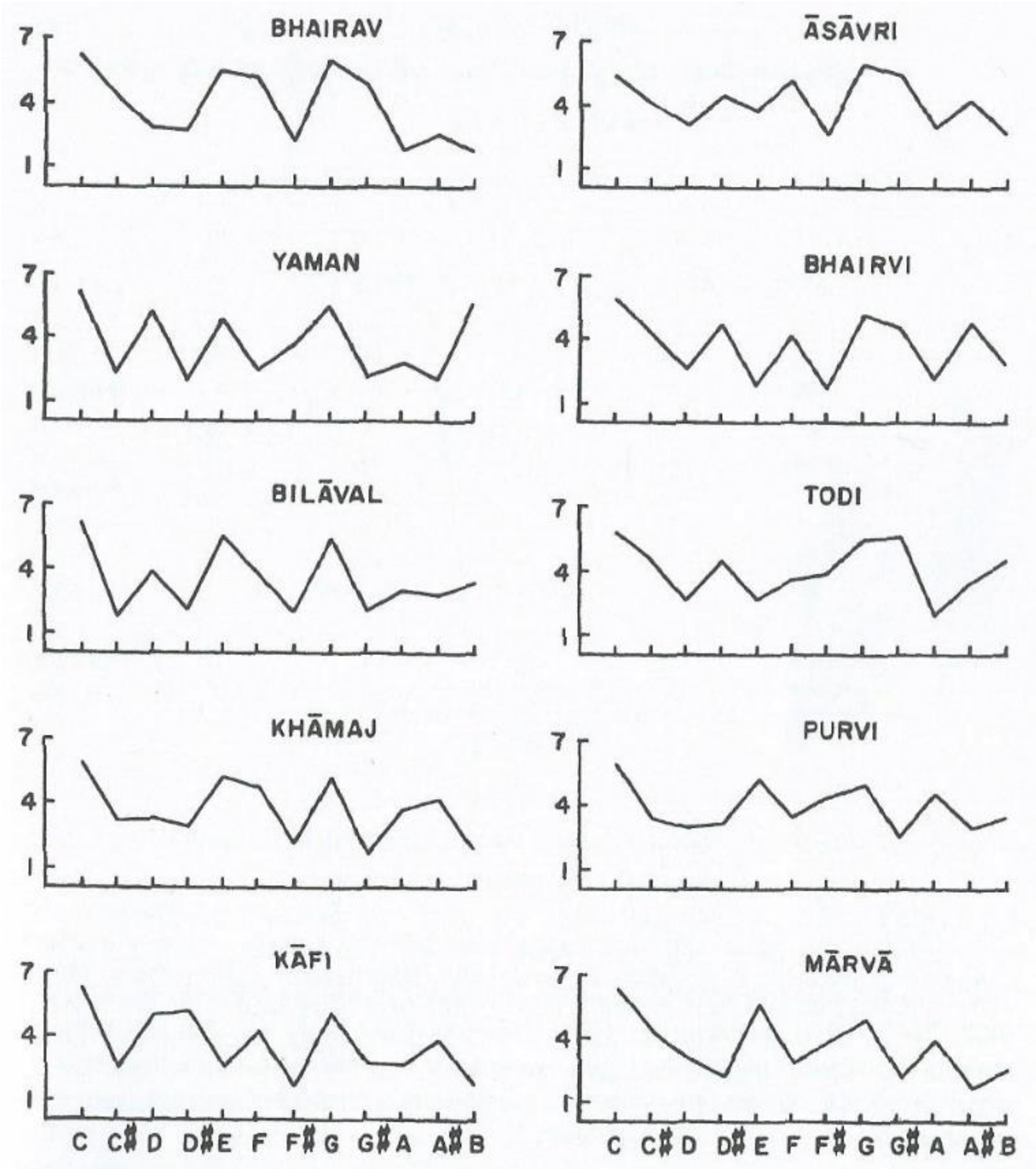
Nevertheless, because the minor triad is common to minor scales and modes, the ratings of its component tones may correspond universally. Unlike the major key hierarchy and Lerdahl's 'basic space' (2001, pp. 47), the minor key hierarchy shows a higher rating for the third (Eb) than the fifth (G). This indicates the following distance order amongst the tones of the minor triad: root, third, fifth. Both the minor and major seventh intervals are rated lower than those of the triad. The high rating given to the minor third and the lower rating of the minor seventh will be challenged by the findings of the spectral analysis.

Reflecting their status as 'Tensions' (Nettles and Graf, 1997, pp. 17) in CST and as members of level d in Lerdahl's 'basic space' (2001, pp. 47), D (9) and A (13) in the major key hierarchy and D and F (11) in the minor key hierarchy have generally lower ratings than the tones comprising the seventh chords. However, the proximal ratings of the pair in each hierarchy does not shed further light on their relative distance. The low ratings attributed to the notes outside of the major and minor keys reflects the unnamed fourth quality of CST organisation and level e of Lerdahl's 'basic space'.

In contrast with CST organisation and Lerdahl's 'basic space', the seventh (B) in the major scale hierarchy is rated lower than the second (D), fourth (F), and sixth (A). Like the seventh in the minor key hierarchy, the low rating is likely because of the voice leading from dominant to tonic in the cadence contexts. The ratings attributed to F in the major key hierarchy and G#/Ab in the minor key hierarchy are other examples of poor correlation with CST. According to CST, these tones are 'Avoid Notes' (Nettles and Graf, 1997, pp. 17) and should be rated lower (more distant) than the 'Tensions'.

The inverse is true in both hierarchies and this will be challenged by the spectral analysis. In the hierarchies, the high ratings of these tones may be attributed to their sounding *after* the harmonic contexts. If they were sounded as Y axis simultaneities with the tonic chords then they would be as heard dissonances, thus receiving a lower rating. Instead, the isolation of these tones converts their dissonance relative to the tonic chord into root potential. In other words, F can be heard as a dissonance relative to the C major triad *and* as the root of its own chord (IV in C major). The latter may contribute to the higher rating.

Krumhansl also reports an experiment which used the probe tone method to derive tonal hierarchies from North Indian classical music (Castellano et al., 1984). Each of the ten rags used for the experiment has a corresponding scale structure. Three of these structures are identical to the Babylonian / Greek / Church modes: Kafi = Dorian; Asavri = Phrygian; and Yaman = Lydian. The findings of the experiment (shown in Example 2.6b) may therefore be valuable for modelling the distance of, not only North Indian classical music, but also modes as they are used in Western harmony.



Example 2.6b: Castellano et al.'s (1984) tonal hierarchies for 'Ten common North Indian rags', as they appear in *Cognitive Foundations of Musical Pitch* (Krumhansl, 2001, pp. 257). Participants were asked to 'rate how well' (pp. 21) each of the twelve tones fit following the melody of each rag on a scale of '1 = "very bad" to 7 = "very good"'. The graphs show the average rating data.

The stimulus materials used in the experiment were the ‘sthayi and theme’ (Krumhansl, 2001, pp. 257) (melody sections) of ‘Ten common North Indian rags’. Unfortunately, like the major and minor key hierarchies, the specific contextual stimuli means that the rag hierarchies conflate distance and motion. The result is the same mixed correlation with the other literature.

According to CST, the ‘Chord Tones’ (Nettles and Graf, 1997, pp. 17) of Dorian and Phrygian form a minor seventh chord (C-Eb-G-Bb) and those of Lydian form a major seventh chord (C-E-G-B). The hierarchies for the equivalent rag scale structures show generally high ratings for these tones. However, there are exceptions with low ratings whilst other scale tones are rated higher. In Kafi (Dorian), for example, D is challenging D#/Eb and is rated higher than A#/Bb. Similarly, in Yaman (Lydian), D is rated marginally higher than E.

Moreover, the relative ratings of the ‘Chord Tones’ in each rag does not correlate entirely with how Lerdahl’s ‘basic space’ (2001, pp. 47) and the ratings of the major and minor key hierarchies. For Yaman (Lydian), the ratings of the ‘Chord Tones’ (Nettles and Graf, 1997, pp. 17) are very similar, with even the seventh (B) challenging the fifth (G). Whilst proximal, the third looks marginally lower than the seventh. These observations contrast with the order drawn from the basic space and the major key hierarchy (root, fifth, third, and seventh) which will be verified by the spectral analysis.

Although they share the minor seventh ‘Chord Tones’, Asavri and Kafi display somewhat different ratings. Whilst Kafi’s distance order of root, third, fifth, seventh correlates with the minor key hierarchy, the fifth in Asavri is rated higher than the third. Whereas Asavri’s distance order of ‘Chord Tones’ is different from Kafi and the minor hierarchy, the spectral analysis will demonstrate Asavri’s to be more accurate – although not wholly correct.

The relative ratings of the ‘Tensions’ in each rag / mode shows a similar level of correlation to that of the ‘Chord Tones’. In Dorian / Kafi, the ‘Tensions’ are D, F, and A – the latter is also considered to be an ‘Avoid Note’ by CST but this will be contested in Chapter 3. The ratings of D and F are proximal whereas A is lower, correlating with the minor key hierarchy. In Lydian / Yaman, the ‘Tensions’ are D, F#, and A. D is shown to be closer than F#, and A is the most distant. These distance orders will be confirmed by the spectral analysis. F is the only ‘Tension’ in Asavri and is curiously rated higher than both the third and seventh ‘Chord Tones’.

According to CST, the ‘Avoid Notes’ in Phrygian / Asavri are Db and Ab, whereas Dorian / Kafi, and Lydian / Yaman do not contain any. In the Asavri hierarchy, the ratings of the ‘Avoid Notes’ compared to the higher ratings of the ‘Tensions’ correlates with CST. Finally, as with the major and minor key hierarchies, the tones outside of each rag have low ratings – again in support of CST’s unnamed fourth quality and level e of Lerdahl’s ‘basic space’ (2001, pp. 47).

In support of the cross-cultural potential of the distance frameworks, ‘Two groups of listeners participated in the experiment’ (Krumhansl, 2001, pp. 257): ‘mostly Indian students studying at Cornell University’ with ‘training in Indian music’; and a second group that was ‘approximately matched in terms of musical experience, but the experience was limited to Western music and instruments’. Krumhansl writes that ‘the two groups produced remarkably similar results; the average intergroup correlations for the 10 rags was .87’ (pp. 259).

Covering the second of the distance types that Lerdahl identified, ‘the relative proximity of chords within a region’ (2001, pp. 45), Krumhansl reports two experiments that account for chord distance across all keys. Modelled on the probe tone experiments, ‘Each trial began with a strong key-defining context followed by a single chord’ (2001, pp. 169); ‘The listener’s task was to rate how well the chord fit’. The ‘context’ of the first experiment ‘was either a major or minor scale played first in ascending form and then in descending form’. To ensure that ‘the sixth and seventh scale degrees were presented in both lowered and raised positions' for the minor key scale context, the 'ascending melodic form and the descending melodic (natural form)' were used.

In the second experiment, the scale context was replaced by 'a sequence that contained all diatonic triads of the two keys of C major and C minor played in their order on the circle of fifths for chords'. In both experiments, listeners were rating the major, minor, and diminished triads based on the 12 chromatic scale tones. Krumhansl writes that 'the results of the two experiments were highly correlated' (pp. 171). The 'average ratings across the two experiments' are shown in Example 2.6c. Whereas Lerdahl (2001) found that the pairs IV and V, iii and vi, and ii and vii°, were equidistant from the tonic, Krumhansl's data shows a clearer order (near to distant): I, IV, V, vi, ii, iii, vii°.

Krumhansl uses the major and minor key tonal hierarchies (shown in Example 2.6a) and the chord distances (shown in Example 2.6c) to derive two measures of 'interkey distance' (pp. 31), or 'relative proximity among tonal regions' (Lerdahl, 2001, pp. 45). The former is based on the argument that 'keys that are close should have similar hierarchies' (Krumhansl, 2001, pp. 34) and was generated by computing the correlation between profiles 'for each possible pair of major and minor keys' (pp. 35)- the results are shown in the left table of Example 2.6d.

Similarly, the chord distances yielded interkey distances by computing the correlation between the 'each of the 24 major and minor keys' (pp. 182). These results are shown in the right table of Example 2.6d. In support of the results, Krumhansl states that the 'virtually identical' (pp. 186) data proves that key distance 'is not a consequence of some property that is special' (pp. 187) to either the major and minor key tonal hierarchies or the chord distances. The data is also 'highly consistent with music-theoretical descriptions' (pp. 186). For example, in accordance with the circle of fifths, both tables show that F major and G major are equidistant from C major, as are Bb major and D major, Eb major and A major, E major and Ab major, and B major and Db major.

Table 7.3. Ratings of chords in harmonic-hierarchy experiments

Chord	C Major Context	C Minor Context
C Major	6.66 (I)	5.30
C♯/D♭ Major	4.71	4.11
D Major	4.60	3.83
D♯/E♭ Major	4.31	4.14 (III)
E Major	4.64	3.99
F Major	5.59 (IV)	4.41
F♯/G♭ Major	4.36	3.92
G Major	5.33 (V)	4.38 (V)
G♯/A♭ Major	5.01	4.45 (VI)
A Major	4.64	3.69
A♯/B♭ Major	4.73	4.22
B Major	4.67	3.85
C Minor	3.75	5.90 (i)
C♯/D♭ Minor	2.59	3.08
D Minor	3.12 (ii)	3.25
D♯/E♭ Minor	2.18	3.50
E Minor	2.76 (iii)	3.33

Table 7.3. (Continued)

Chord	C Major Context	C Minor Context
F Minor	3.19	4.60 (iv)
F♯/G♭ Minor	2.13	2.98
G Minor	2.68	3.48
G♯/A♭ Minor	2.61	3.53
A Minor	3.62 (vi)	3.78
A♯/B♭ Minor	2.56	3.13
B Minor	2.76	3.14
C Diminished	3.27	3.93
C♯/D♭ Diminished	2.70	2.84
D Diminished	2.59	3.43 (ii°)
D♯/E♭ Diminished	2.79	3.42
E Diminished	2.64	3.51
F Diminished	2.54	3.41
F♯/G♭ Diminished	3.25	3.91
G Diminished	2.58	3.16
G♯/A♭ Diminished	2.36	3.17
A Diminished	3.35	4.10
A♯/B♭ Diminished	2.38	3.10
B Diminished	2.64 (vii°)	3.18 (vii°)

Example 2.6c: Krumhansl's chord distances (2001, pp. 171). In two experiments, participants were asked to 'rate how well' (pp. 169) major, minor, and diminished triads based on the 12 chromatic scale tones 'fit' following key-defining contexts. The tables show the 'average ratings across the two experiments'.

Table 2.4. Correlations between key profiles

	C Major	C Minor
C major	1.000	.511
C♯/D♭ major	−.500	−.158
D major	.040	−.402
D♯/E♭ major	−.105	.651
E major	−.185	−.508
F major	.591	.241
F♯/G♭ major	−.683	−.369
G major	.591	.215
G♯/A♭ major	−.185	.536
A major	−.105	−.654
A♯/B♭ major	.040	.237
B major	−.500	−.298
C minor	.511	1.000
C♯/D♭ minor	−.298	−.394
D minor	.237	−.160
D♯/E♭ minor	−.654	.055
E minor	.536	−.003
F minor	.215	.339
F♯/G♭ minor	−.369	−.673
G minor	.241	.339
G♯/A♭ minor	−.508	−.003
A minor	.651	.055
A♯/B♭ minor	−.402	−.160
B minor	−.158	−.394

Table 7.10. Correlations between harmonic hierarchies

	Key	
Key	C Major	C Minor
C Major	1.000	.738
C♯/D♭ Major	−.301	−.224
D Major	−.141	−.320
D♯/E♭ Major	−.013	.405
E Major	−.139	−.256
F Major	.297	.194
F♯/G♭ Major	−.407	−.281
G Major	.297	.175
G♯/A♭ Major	−.139	.123
A Major	−.013	−.286
A♯/B♭ Major	−.141	.031
B Major	−.301	−.298
C Minor	.738	1.000
C♯/D♭ Minor	−.298	−.373
D Minor	.031	−.189
D♯/E♭ Minor	−.286	.072
E Minor	.123	−.096
F Minor	.175	.245
F♯/G♭ Minor	−.281	−.321
G Minor	.194	.245
G♯/A♭ Minor	−.256	−.096
A Minor	.405	.072
A♯/B♭ Minor	−.320	−.189
B Minor	−.224	−.373

Example 2.6d: Krumhansl's 'interkey' (2001, pp. 31) distances calculated from: (left) correlation between tonal hierarchies (pp. 353), and (right) correlation between chord distances (pp. 183).

To recap the literature concerned with the ‘distance’ of Gravitonicity: Schoenberg (1978) conceived of the major scale as a distance framework; Hindemith derived a ‘natural’ (1941, pp. 55) order from a single ‘progenitor tone’ (pp. 54); Russell treated each chord as a ‘VERTICAL TONAL GRAVITY CENTERING ELEMEMT’ (2001, pp. 102) with a corresponding ‘Lydian Chromatic Scale’ (pp. 12) that represents a ‘close to distant relationship’ (pp. 3) for each pitch; CST promises distance frameworks that can be mapped to any harmonic context, albeit with only ‘three qualities’ (Nettles and Graf, 1997, pp. 17) (and seemingly a fourth) representing the distance levels; Tomaro and Wilson’s sequences of ‘tension and density’ (2009, pp. 385) demonstrate distance but conflate it with voicing; Lerdahl’s ‘basic space’ (2001, pp. 47) resonates with CST and perhaps points to an order for the relative distances of the ‘Chord Tones’ (Nettles and Graf, 1997, pp. 17); and Krumhansl’s (2001) tonal hierarchies, although conflating distance with motion, represent quantified accounts of the distance.

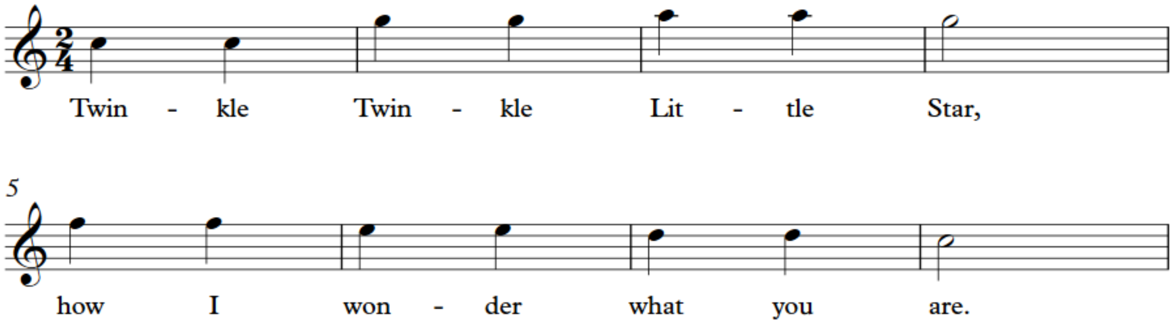
Lastly, despite not being the focus of this research, Lerdahl and Krumhansl’s measures of chord and key distance illustrate a broader picture of distance for Gravitonicity. These were covered because they stem from the ‘basic space’ (Lerdahl, 2001, pp. 47) and tonal hierarchies (Krumhansl, 2001), and not as part of an exhaustive literature review on chord and key distances. Dmitri Tymoczko, for example, offers an alternative means of deriving key distances through ‘voice-leading distance between scales’ (2011, pp. 250), with similar results to Krumhansl (2001). On the other hand, Andrew J Milne and Simon Holland use spectral analysis to argue that ‘the number of common tones between chords (abstracted across voices and octaves) is a highly effective predictor of their perceived distance’ (2016, pp. 83).

2.7: *Musical Forces* (Larson, 2012)

Now that the literature on distance frameworks has been reviewed, attention can be returned to the problematic 'motion' (Rothfarb, 2002, pp. 929; Zuckerkandl. 1956, pp. 95) that may inhabit them. Motion, like the chord and key distances, is not the focus of this research but is an indispensable ingredient of Gravitonicity. Steve Larson's posthumously published *Musical Forces* (2012) offers a detailed perspective on motion that seemingly subsumes similar earlier literature through a systematic review e.g., Narmour, 1990; Bharucha, 1996; Lerdahl, 2001; Margulis, 2003 etc. Larson identifies and defines:

> three melodic forces ("melodic gravity" is the tendency of notes above a reference platform to descend; "melodic magnetism" is the tendency of unstable notes to move to the closest stable pitch, a tendency that grows stronger as the goal pitch is closer; and "musical inertia" is the tendency of pitches or durations, or both, to continue in the pattern perceived)'
> (2012, pp. 2)

The text illustrates the effects of the 'three melodic forces' with an analysis of "Twinkle, Twinkle, Little Star" (shown in Example 2.7a). Larson explains that 'the first note (C) provides a base' (pp. 83) (the 'reference platform' (pp. 2)) to which 'melodic gravity pulls all those other notes down' (pp. 83). The 'magnetic attractor(s)' (pp. 89) in the extract are 'C, E, and G – the members of the tonic triad' (pp. 88). Because F is 'closer' (pp. 2) to E than G, the movement from F to E in bars five and six 'may be heard as giving in to melodic magnetism' (pp. 88).



Example 2.7a: Bars 1-8 of "Twinkle, Twinkle, Little Star".

Lastly, in terms of '"musical inertia"' (pp. 2), 'If measures 3 and 5 are heard as resolving down by step into their following measures, then measure 7 may be heard as giving in to inertia when continues that same pattern of resolution' (pp. 97). Furthermore, unlike '"melodic gravity"' and '"melodic magnetism"' (pp. 2), '"musical inertia"' extends to duration. This is evidenced in Example 2.7a by the rhythmic pattern established in measures 1-4 being repeated in measures 5-8.

Significantly, although he does not undertake 'a complete specification of the theory' (pp. 118), Larson 'assumes that we hear passages' and thus understand the 'three melodic forces' (pp. 2) in terms of 'an important stream of jazz theory' (pp. 117): CST. He describes a 'hierarchical nesting' through which 'the chromatic scale provides motion through the more stable "parent" chord-scale, which in turn provides motion through the more stable chord'.

This 'nesting' is expressed by the 'three qualities' (Nettles and Graf, 1997, pp. 17) – and the chromatic scale as the potential fourth quality – of the chord scales. Using CST as a gateway, the distance frameworks developed in this research will offer a finer distinction of the levels that comprise the ‘hierarchical nesting’ (Larson, 2012, pp. 117). Consequently, they may represent a set of tools to investigate motion more deeply in future research.

Because the individual distance frameworks are the focus of this research, the current presentation of motion will not extend to the forces between them e.g., Schenker’s ‘Ursatz’ (1979, pp. 18), Ernst Kurth’s ‘potential energy, in chords’ (Rothfarb, 2002, pp. 940), Kenneth M Smith’s ‘Drive Analysis’ (2020a; 2020b) etc. However, it will become clear that these types of motion / force may be understood as a by-product of the functional relationships that are constructed through the sequential arrangement of the distance frameworks.

Larson’s contributions to the ‘neutral level’ (Nattiez, 1990, pp. 12) understanding of motion are framed within the central argument of his work: ‘we not only *speak* about music as if it were shaped by musical analogs of physical gravity, magnetism, and inertia, but we also actually *experience* it in terms of “musical forces”’ (Larson, 2012, pp. 1). Whilst this line of inquiry enters the ‘esthesic dimension’ (Nattiez, 1990, pp. 12), it is not intended to elaborate the listener’s subjective experience and how it may challenge the ‘neutral level’ understanding of Gravitonicity. Instead, unlike any literature reviewed thus far, Larson’s argument resonates with and brings clarity to RQ1 (what is Gravitonicity?).

Larson’s argument for our experience of musical motion is founded on George Lakoff and Mark Johnson’s theory of conceptual metaphor (1980; 1999). In *Metaphors We Live By* (1980), Lakoff and Johnson claim that:

> metaphor is typically viewed as a characteristic of language alone, a matter of words rather than thought or action. We have found, on the contrary, that metaphor is pervasive in everyday life, not just in language but in thought and action. Our ordinary conceptual system, in terms of which we both think and act, is fundamentally metaphorical in nature. […] the way we think, what we experience, and what we do every day is very much a matter of metaphor. (pp. 1)

Drawing from and paraphrasing the work of Lakoff and Johnson, Larson offers a concise explanation of how these metaphorical relationships are structured and, importantly, from where they are derived:

> "if everything is understood in terms of something else, how is that 'something else' understood?" What prevents an infinite circular regress? Metaphors form coherent webs of mutually reinforcing relationships, and so, to an extent, we do have an infinite circular regress. Yet, if metaphors help us to understand new things in terms of familiar things, then those familiar things will tend to belong to source domains that are more basic in our experience. And our most basic experiences are physical. (2012, pp. 48)

Metaphors, therefore, are grounded in our physical experiences. These experiences are shaped by 'how we are embodied' (Lakoff and Johnson, 1999, pp. 18): 'the brains and bodies we have' and the way 'we interact in the world'. In *Musical Forces* (2012), Larson co-authors a chapter with Johnson that details the metaphor 'Musical Succession Is Physical Motion' (pp. 82). They argue that 'basic experiences of physical motion give rise, via metaphor, to the chief ways in which we conceptualize and experience musical motion' (pp. 61). An 'important entailment' (pp. 82) of the metaphor are 'melodic gravity', 'melodic magnetism', and 'musical inertia', which we experience through our 'intuitive embodied understanding' of the analogous physical forces of gravity, magnetism, and inertia.

This literature review has shown that Gravitonicity comprises both 'distance' and 'motion', each with their respective challenges. In response to RQ1 ('What is Gravitonicity?'), Larson, using conceptual metaphor theory (Lakoff and Johnson, 1980; 1999), has argued that our experiences of 'motion' in music are metaphorically grounded in an 'intuitive embodied understanding' (Larson, 2012, pp. 82) of physical forces. In accordance with Larson's work, Chapter 3 will complete a response by showing how the perceived 'distance' may be metaphorically grounded in our embodied experience of 'spatial-relations concepts' (Lakoff and Johnson, 1999, pp. 31). The prospects of universality for both metaphors will also be addressed.

Chapter 3: Methodology

This Chapter will officially and systematically introduce Gravitonicity, a name (and category of logic) that may come to be synonymous with harmony itself. The methodology is built from the following research questions:

RQ1: What is Gravitonicity?

RQ2: How and to what extent is it possible to derive a model of Gravitonicity from the 'neutral level' (Nattiez, 1990, pp. 12)?

RQ3: How does the listener construct the meaning (Nattiez's 'esthesic dimension') of Gravitonicity and to what extent can this lead to a subjective experience?

RQ2 will be responded to first, then RQ1, and finally RQ3. The 'neutral level' response to RQ2 cannot completely neutralise the 'esthesic dimension' because the latter is where we construct meaning. Instead, it offers a music-theoretic description of how 'the musical text' gives rise to our constructed meaning of 'distance' and 'motion'. This description is ultimately represented as a 'neutral level' model of Gravitonicity.

The research design for RQ2 may be typified as a 'convergent mixed methods' approach (Creswell & Creswell, 2018, pp. 15), involving the convergence of 'qualitative and quantitative data in order to provide a comprehensive analysis of the research problem'. As a description of 'the musical text' (Nattiez, 1990, pp. 12), the 'neutral level' model is predominantly qualitative. However, to observe the harmonic spectra, quantitative data is produced using software and empirically interpreted. The findings are integrated with the qualitative elements in the 'neutral level' model.

The responses to RQ1 and RQ3, on the other hand, are purely qualitative. At the end of Chapter 2, it was discussed how Steve Larson (2012) used conceptual metaphor theory (Lakoff and Johnson, 1980; 1999) in explanation of the 'motion'. The response to RQ1 will acknowledge Larson's conception of the 'motion' and similarly draw upon George Lakoff and Mark Johnson's ideas to explain the 'distance'. To bring maximum clarity to the 'distance', this section will integrate the essentials of the 'neutral level' (Nattiez, 1990, pp. 12) model.

The response to RQ3 will address the subjective experience of Gravitonicity by drawing upon John Shepherd and Peter Wicke's 'Semiological model' (1997, pp. 173). Their work models how we construct meaning when listening to music, i.e., the 'esthesic dimension' (Nattiez, 1990, pp. 12). Significantly, it creates space for a 'SLIPPAGE' of meaning which can result in different experiences of Gravitonicity for 'different individuals and in the same individual at different times' (Shepherd and Wicke, 1997, pp. 175).

The 'SLIPPAGE' and several other components from the 'Semiological model' (pp. 173) feed forward to the culminative step of the methodology: the full model of Gravitonicity. The full model houses the responses to all three research questions: what Gravitonicity is, the 'neutral level' (Nattiez, 1990, pp. 12) model, and the role of the listener's subjective experience.

3.1: Research Question 2

Chapter 2 showed that Gravitonicity comprises ‘distance’ and ‘motion’. It was explained that distance is the focus of this research, which may represent an opportunity to understand motion more deeply in future research. This potential opportunity has been positioned towards the end of the RQ2 section of the methodology.

Pitch will be treated as the exclusive ingredient of the distance. This is in agreeance with all the distance-related literature reviewed in Chapter 2 e.g., Schoenberg (1978 – originally published in 1911), Hindemith (1941), Russell (1953/2001), Nettles and Graf (1997), Tomaro and Wilson (2009). Lerdahl (2001), and Krumhansl (2001). Given their importance to Gravitonicity, the pitches will be referred to as ‘gravi-tone(s)’. This is an appropriation of the term ‘graviton’ (Rothman and Boughn, 2008) (the hypothetical quantum of gravity) from the field of physics.

The equation shown in Example 3.1a, which first featured in *Philosophiæ Naturalis Principia Mathematica* (transl. The Mathematical Principles of Natural Philosophy) in 1687, is Sir Isaac Newton’s Universal Law of Gravitation. Although it has been superseded by Albert Einstein’s Theory of General Relativity (1920) (and gravitation in general remains a negotiable category), Newton’s Law offers a clear illustration of how the force fundamentally works.

$$F_g = G\frac{m_1 m_2}{r^2}$$

Example 3.1a: Newton’s Universal Law of Gravitation (1687). ‘F_g’ is the gravitational force, ‘G’ is the ‘constant’, and the masses (‘m_1’ and ‘m_2’) are inversely proportional to the square of the distance (‘r^2’) between them.

This research only requires one component from Newton's equation: that the mass of an object determines its gravitational pull. The parallel for Gravitonicity is that each pitch (gravi-tone) embodies a 'mass'. It is important to note that the gravi-tones do not have a literal physical mass, rather they each embody a context-specific significance. This 'mass' / significance is determined by distance and motion. As noted above, motion will be discussed in the latter stages of the RQ2 methodology.

The distance of the gravi-tones will be measured by a 'gravi-tone value(s)', or '*g*'. Because this work aims to offer practical tools that are widely accessible to practitioners, analysts, and educators from all musical backgrounds, the gravi-tones and their *g* values will be based upon twelve-tone equal temperament. In accordance with the twelve-part organisation of equal temperament, the *g* values will be rated on a scale of 1-12.

The gravi-tone that contextually embodies *g*1 acts as the 'progenitor tone' (Hindemith, 1941, pp. 54) / 'sun' (pp. 57) / 'central star' / '"Sun Absolute"' (Russell, 2001, pp. 3), whilst the gravi-tones that contextually embody *g*2-*g*12 represent a 'close to distant relationship' (pp. 3) / 'diminishing degree of relationship' (Hindemith, 1941, pp. 56) from *g*1 e.g., *g*2 is the closest, *g*3 is the second closest, and *g*12 is the most distant.

Two factors make the gravi-tones and their *g* values specific to equal temperament. Firstly, it was stated in Chapter 2 that *The Chord Scale Theory & Jazz Harmony* (Nettles and Graf, 1997) (hereby CST) would play an important part in the methodology. The CST text only makes two references to tuning, stating that equal temperament 'allows one to transpose and play music in all keys' (pp. 12) and means that 'modes can be transposed' (pp. 13). This emphasis on equal temperament suggests that CST may be challenged to varying degrees and in unique ways by other tuning systems.

Secondly, it was also stated in Chapter 2 that spectral analysis would be undertaken to discern the *g* values within the 'three qualities' (pp. 17) – and a potential fourth quality – of the chord scales. The observed harmonic spectra correspond to various equally-tempered tone combinations, meaning that the spectra are also influenced by the tempering. As a result, the derived *g* values are specific to equal temperament.

Nevertheless, in future research, the same methodology could be employed for other tuning systems by analysing the spectra of appropriately-tuned pitches. Depending on the tuning system, changes may be required to CST or an alternative system of harmonic organisation may be needed in its place. For tuning systems with more / fewer tones, the number of *g* values may be increased / decreased. Alternatively, if *g*12 is understood as the most distant (perhaps even across tuning systems), then decimals could be used between *g*1 and *g*12. In the quarter tone system, for example, then '.5' values could be interspersed between the twelve values e.g., *g*1, *g*1.5, *g*2 etc.

In this present work, the gravi-tones will be represented by a scale degree numbering system that attributes names to intervals across two octaves for all scales and modes. This system (shown in Example 3.1b) has been borrowed from CST (Nettles and Graf, 1997). With C as 1/*g*1, each scale degree is shown with a representative pitch class. It is always the case that the gravi-tone acting as scale degree 1 will embody *g*1. The remaining *g* values (*g*2-*g*12) can embody any of the other scale degrees.

*g*1	*g*2 – *g*12										
1	**b9**	**9**	**#9/-3**	**3**	**sus4/11**	**#11/b5**	**5**	**+5/b13**	**6/13/°7**	**-7**	**maj7**
C	Db	D	D#/Eb	E	F	F#/Gb	G	G#/Ab	A	Bb	B

Example 3.1b: CST scale degree numbering with corresponding *g* values.

For clarity, one minor alteration has been made to the CST scale degree numbering system: ‘b5’ will account for both ‘b5’ and ‘°5’ contexts (the latter is only ordinarily used for diminished chords). It is also worth noting that ‘7’ is commonly used in jazz to indicate minor seventh. Nettles and Graf acknowledge this but, to make the distinction clearer between minor and major seventh intervals, they suggest ‘-7’ and ‘maj7’ respectively. In the interests of maximum clarity, this research will follow suit. The authors also acknowledge the existence of ‘sus2’ which is ‘more common in popular/rock styles’ (pp. 24). However, unlike ‘sus4’, it is not systematised within their work and is consequently not included here either.

Because the gravi-tones are based on equal-temperament, they could have been represented using pitch class numbering e.g., C = 0, C#/Db = 1 etc. However, similarly to equal-temperament, the CST scale degree numbering system was chosen for practicality and accessibility. There is a generally convenient interchangeability in the terminology used for intervals, scale degrees, and (in some cases) chord names e.g., an augmented fifth chord contains an augmented fifth interval in which, if the root of the chord is scale degree 1, the upper note is the +5 scale degree.

It is far less convenient to consider or calculate an augmented fifth interval being a span of eight semitones, which is what speaking/thinking in pitch class numbering terms would require. Whilst both approaches meet the same ends, the latter incurs unnecessary hindrances for the reader who is already familiar with the language of basic music theory.

In analogy to Newton’s Law, the gravi-tones have become the objects and their distance (‘mass’ / significance) is represented by a gravi-tone value (*g*). However, in place of the ‘F_g’ – the gravitation itself – a name still needs to be placed for Music’s ‘gravitation’. The term ‘tonicity’ has been used lightly in the music theory and analysis literature (Butler, 1983, pp. 251; Tagg, 2014, pp. 426; Nikolsky, 2015, pp. 8) to generally mean the extent to which a pitch sounds as a tonic. Any of the twelve gravi-tones have the potential to be embodying *g*1 and their relative distances can be considered as representing degrees of tonicity. The gravi-tones, with their relative degrees of tonicity, are the mediators of Gravitonicity. Example 3.1c shows the distance equation of Gravitonicity.

$$F_G = 1_g \mid b9_g \mid 9_g \mid \#9/{-3}_g \mid 3_g \mid sus4/11_g \mid \#11/b5_g \mid 5_g \mid +5/b13_g \mid 6/13/°7_g \mid -7_g \mid maj7_g$$

Example 3.1c: The distance equation of Gravitonicity: ‘F_G’ is Gravitonicity; this is comprised of the twelve gravi-tones (shown as scale degrees); and each of the twelve gravi-tones have a corresponding *g* value.

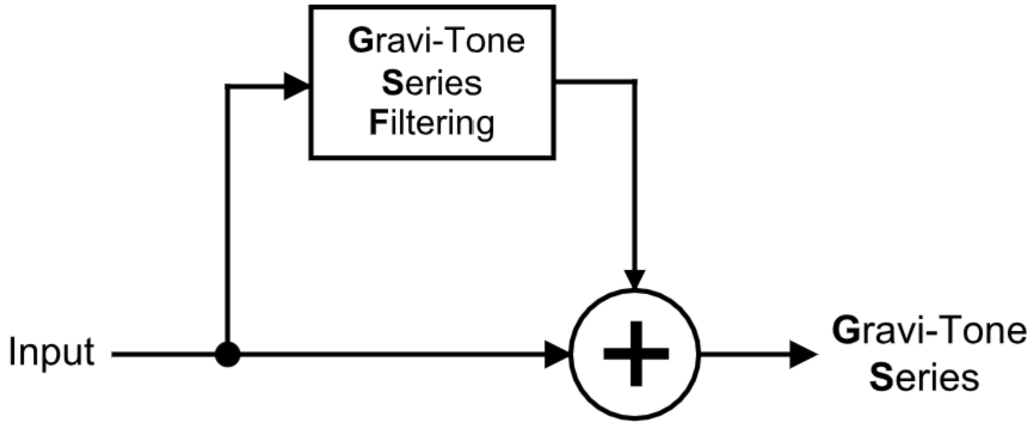
3.2: Gravi-Tone Series Filtering

With the distance equation in place, the next step was to address how the *g* values are allocated and, in doing so, demonstrate how Gravitonicity works. As discussed above, ‘context’ determines the *g* value for each gravi-tone. The context is functionality, for which a short account of the key figures and their contributions was given in section ‘1.2: The Evolution of Harmony in Western Music’. This account included the following explanation of the term from *The Chord Scale Theory & Jazz Harmony* (Nettles and Graf, 1997, pp. 30):

> Every chord has a function or tonal responsibility. When we hear a chord progression we match each chord sound to a function. How is the chord working to make the music progress forward? Our subconscious instantly justifies the chord’s function as it passes our mind’s ear even if it is a chord one had previously not expected to hear. Perception of function occurs in a split second. The more experienced the listener, the better the understanding of how each event relates to the total picture.

Whereas the text goes on to traditionally categorise all chords within ‘the three functional sounds of tonic, sub-dominant, and dominant’ (pp. 30), defining functionality for Gravitonicity will be handled differently and with greater specificity.

The functions of Gravitonicity are Gravi-Tone Series’ (GS’), specific mappings of the twelve *g* values onto the twelve gravi-tones. Akin to the CST conception of functionality, the GS’ are ‘instantly’ justified by ‘our sub-conscious’. This occurs through a psychological process called Gravi-Tone Series Filtering (GSF). GSF works as a ‘feed-forward’ (Gordon, 1995, pp. 185) ‘filter’: ‘devices that boost or attenuate regions of a sound spectrum’ by ‘delaying a copy of an input signal slightly […] and combining the delayed input signal with the new input signal’. This process is outlined in Example 3.2a.



Example 3.2a: Gravi-Tone Series Filtering (GSF) mapped onto the 'feed-forward' (Gordon, 1995, pp. 185) 'filter' diagram from *The Computer Music Tutorial*. The 'Input' (sound) is analysed by the 'delay' process, GSF, leading to the 'Output': a Gravi-Tone Series (GS).

The 'Input' of the process is sound as it meets the ear, the gateway to our internal world. To start the process, the 'Input' must contain at least one pitch. At this stage, the twelve pitch classes – which may or may not be part of the 'Input' – are not yet gravi-tones. They acquire this status through our attribution of meaning (*g* values) at the 'Output': a GS. The 'delay' process by which this happens, GSF, will be the focus of the RQ2 methodology. GSF analyses four qualities of the 'Input':

(1) the present tone(s) (as they would appear in traditional notation),

(2) their harmonic spectra,

(3) memory traces of preceding tones, and

(4) the unified time dimension (Z axis).

Collectively, this information determines the *g* values (relative distance) for all twelve gravi-tones. Gravi-tones that are most strongly represented by the four qualities have 'boosted' *g* values (closer to *g*1), whereas those which are weakly represented are 'attenuated' (closer to *g*12). It will be shown that the relative influence of each quality on GSF is context-specific and that even a single quality can be sufficient. The coming pages will discuss an array of GS' and how the four qualities of GSF lead to their attribution.

3.3: Identifying *g*1

The most basic example of an input to GSF is a single present tone. Due to its apparent isolation, the single tone can logically be attributed with *g*1. In contexts with multiple present tones, *g*1 is determined by the 'fundamental tone' (originally theorised by Jean-Phillippe Rameau): 'each chord has a fundamental tone, equivalent in most cases to what is today called its root […] In a series of chords, the succession of these fundamental tones is the fundamental bass' (Burkholder et al., 2014, pp. 425). To illustrate this, Example 3.3a shows a D minor seventh chord in root position and first inversion (Rameau's "sixte ajoutè" / added sixth if in the key of C major).

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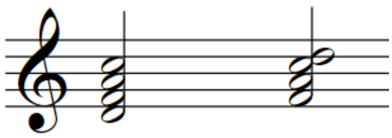
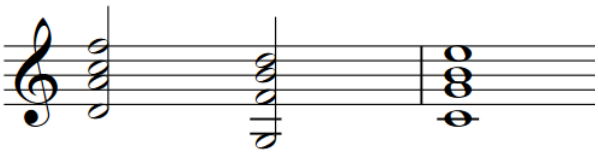


Example 3.3a: D minor seventh chord in root position and first inversion.

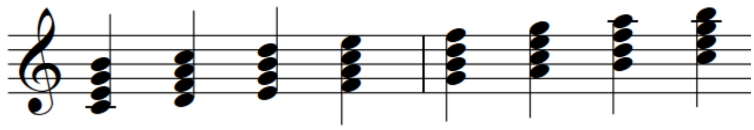
Despite sharing the ‘D minor seventh’ chord name, the lowest note of each structure means that they do not share the same fundamental tone / *g*1. When there are no clarifying memory traces of preceding tones, the ‘first inversion D minor seventh’ is heard as a root position F major sixth chord.

Importantly, the fundamental tone of a chord does not need to be a present tone if there are preceding chords that provide sufficient contextualisation. Richard Parncutt (1996) posits the useful label ‘perceptual roots’ (p. 181) for such occurrences in tonal contexts. Example 3.3b shows a ii-V-I progression as seventh chords in the key of C major. If the fundamental of D minor seventh were omitted on the first listening, then the chord would likely be interpreted as an F major triad in first inversion. However, if omitted after multiple cycles of the progression, then the listener’s expectations may lead them to infer D as a ‘perceptual root’.



Example 3.3b: ii-V-I in C Major.

Example 3.3c shows root position seventh chords ascending stepwise through the major scale. As with Example 3.3b, omitting bass notes before the listener is suitably contextualised will mean that they are unable to infer the ‘true’ fundamental tones. However, as the listener becomes increasingly acclimatised to the pattern, the removal of a chord root becomes less problematic. For example, because it occurs later in the progression, it would be easier to infer the bass of A minor seventh than E minor seventh.

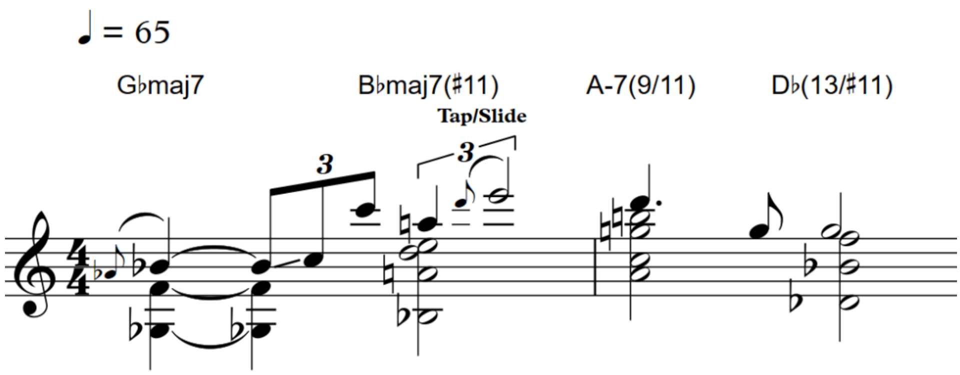


Example 3.3c: Root position seventh chords ascending stepwise through the major scale.

The contextualisation that enables the 'perceptual roots' need not be tonal. Example 3.3d shows a series of root position major seventh chords ascending by whole tones. As with Example 3.3c, the listener becomes increasingly acclimatised to the pattern as it progresses and thus more capable of inferring a 'perceptual root' if one is omitted. It may be argued, however, that the lack of a tonal frame of reference means that learning the pattern requires more of it to be heard. For example, whereas it might be claimed that the listener is able to infer a 'perceptual root' by the E minor seventh in Example 3.3c (chord three), the same ability may not be possible until the Gb major seventh (chord four) in Example 3.3d.

Example 3.3d: Root position major seventh chords ascending by whole tones.

Examples 3.3a through 3.3d illustrate how *g*1 can be identified as the fundamental tone of individual chords. However, GS' are not restricted to the isolable events of the single present tone and multiple super-imposed present tones (chords). They also persist through combination of the X and Y axes. Example 3.3e shows the first two bars of *Gora (Wood)* (Shufflebotham, 2020b), an Ilija Pejovski composition arranged for the solo guitar. There are two chords in the first bar, each with a fundamental tone (namely Gb and Bb). In both cases, the fundamentals / *g*1's and their inhabited GS' persist until there is a clear change in the fundamental bass e.g., the GS in which Gb is *g*1 is present until the bass moves to Bb, and likewise for the changes to A and Db.



Example 3.3e: The first two bars of *Gora (Wood)* (Shufflebotham, 2020b) for solo guitar.

Although the durations of the fundamentals match that of their respective GS' in Example 3.3e (each lasting for two beats), this is not a requirement for GS' to persist. For example, if the duration of the Gb fundamental were shortened to any value less than two beats (dotted crotchet / crotchet / quaver etc), it would persist as a trace in the memory of the listener until it is supplanted by the Bb fundamental. Consequently, the gravi-tones following the shortened Gb fundamental are still heard in relation to it as *g*1. This can be considered as another type of inferred ‘perceptual root’ (Parncutt, 1996, pp. 181) and will be seen to be common in the analysis of Chapter 4.

This type of ‘perceptual root’ that ensues as a memory trace is also identifiable in monophonic passages, i.e., dimensional combination X/Z/T. Example 3.3f shows the bass and piano riff of the jazz standard *So What* (Davis, 1959b). D is established as the fundamental of the phrase because: (1) it is sounded first and is thus the first to leave a memory trace; (2) it is the present tone of the phrase in addition to making its presence known an octave higher; (3) whilst its first and second soundings arguably fall on metrically weak positions (off-beats of 1 and 3), its authority as *g*1 is stamped by the semibreve in the second bar; and (4) the present tones that unfold throughout the riff and in the piano correspond to the D Dorian mode.

Example 3.3f: Bass and piano riff in *So What* (Davis, 1959b).

Beyond the basic recognition of the central role of the fundamental tone, there is seemingly little research into root / *g*1 identification in chords. A recent study into the area (Giannos and Cambouropoulos, 2017) highlights only two significant contributions: Paul Hindemith's concept of 'Interval roots' (1941, pp. 68), which 'isn't accepted by many theorists' (Giannos and Cambouropoulos, 2017, pp. 5); and a model by Richard Parncutt (1996), which looks promising but still faces a 'paucity of systematic tests' (pp. 197).

Although a valuable tool, using the lowest tone (present or 'perceptual') to determine *g*1 should not be assumed to be totally infallible. Parncutt offers the second inversion major triad heard without context as an example. He explains that, whilst the 5th acts as a potential root because it is the lowest note in the chord, 'the 4th above the bass (the tonic)' (pp. 185) also acts as a potential root because of his 'theory of root-support intervals'. The root / *g*1 of this chord is certainly ambiguous and other such examples likely exist, particularly when accounting for memory traces of preceding tones. Therefore, for the analysis of Chapter 4, the reader is encouraged to consider alternative *g*1 justifications to the ones given and, subsequently, alternative GS'.

3.4: The Chord Scale Theory

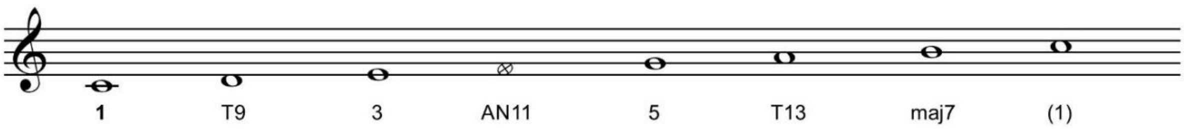
With a method in place for identifying *g*1 in any context, the next step is to address the remaining *g* values (*g*2-*g*12). An important tool that will be used to achieve this is Chord Scale Theory (hereby CST). In the words of Nettles and Graf (1997), CST:

> describes the interrelation between chords and scales. They form a functional unity with two different manifestations, each representing the qualities of the other. Chords form a vertical structure of notes (tertian structure), while scales describe a horizontal one (stepwise order). Extended chord structures (thirteenth chords) contain all notes of the appropriate scale. If this vertical structure is turned into a horizontal line, the chord becomes the corresponding scale and vice versa. […] The function of a chord in relation to a tonal center determines its structure plus corresponding scale (= chord scale). […] Chord scales have three qualities: 1. Chord Tones: The basic chord structures are seventh chords. 2. Tensions: Additional tones which create special sound colors and tension. 3. Avoid Notes: Tones of a chord scale, which sound very dissonant and therefore are avoided harmonically. (pp. 16-17)

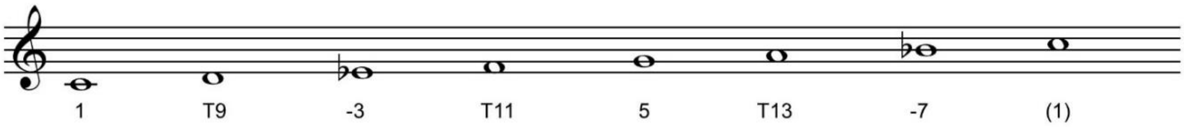
The most common ‘chord scales’ of CST (compiled in Example 3.4a) include: the modes (Ionian, Dorian, Phrygian etc) that Chapter 1 traced from the Babylonian writings through to ‘the new modalism’ (Vieru, 1993, pp. 16); scales which gained prominence during the evolution of tonal music (melodic minor, altered, Lydian b7 – the latter two may not yet be familiar to the reader); and symmetrical scales (symmetric diminished and symmetric dominant – otherwise known respectively as the whole-half and half-whole octatonic scales – and whole-tone).

Example 3.4a: The Chord Scale Theory. The most common ‘chord scales’ (Nettles and Graf, 1997, pp. 17) include the modes, scales which gained prominence during the evolution of tonal music, and symmetrical scales. Each ‘chord scale’ has two or three qualities: ‘Chord Tones’ (CT’s), ‘Tensions’ (T’s), and, if applicable, ‘Avoid Notes’ (AN’s). The CT’s form a seventh chord which is indicated next to the name of each chord scale.

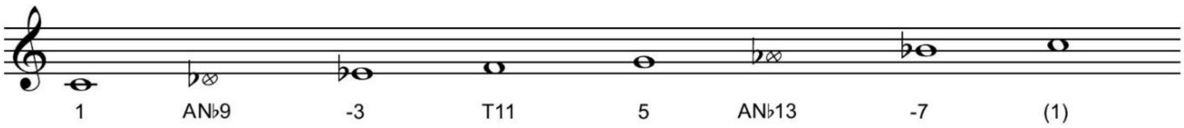
Ionian = maj7



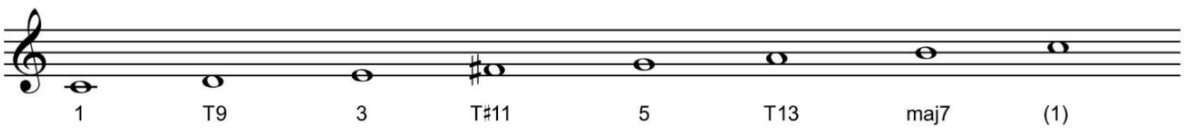
Dorian = -7



Phrygian = -7



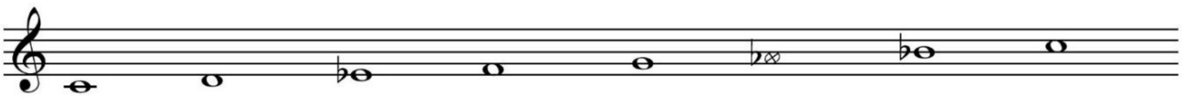
Lydian = maj7



Mixolydian = 7

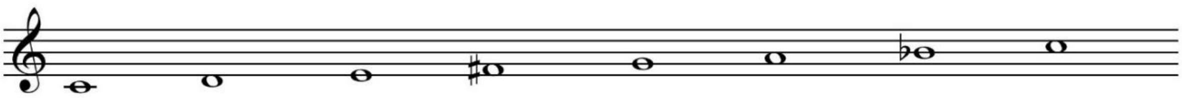
Mixolydian 7sus4 = 7sus4

Aeolian = -7



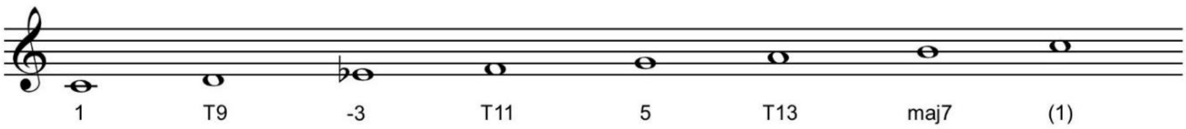
Locrian = -7♭5

Lydian ♭7 = 7



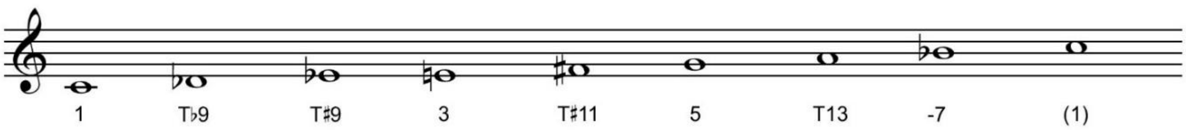
altered = 7no5

melodic minor = -maj7

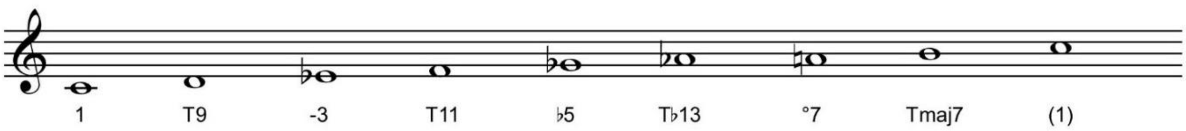


whole-tone = +7 and 7♭5

symmetric dominant = 7



symmetric diminished = °7



The organisation of the chord scales into ‘Chord Tones’ (Nettles and Graf, 1997, pp. 17) (CT’s), ‘Tensions’ (T’s), and ‘Avoid Notes’ (AN’s) represents a pre-existing framework that mirrors the function of the *g* values (distance). From Nettles’ and Graf’s descriptions above, the categories of CT/T/AN can be interpreted as indicating *g* values that are progressively further from *g*1. The recognition of the CST qualities as a *g* value framework will receive greater justification in the following sections.

To illustrate the ‘three qualities’ (Nettles and Graf, 1997, pp. 17) of the chord scales, observe the Ionian (major scale) chord scale in Example 3.4a. The ‘Chord Tones’ (hereby CT’s – 1 3 5 maj7) form a major seventh chord, the ‘Tensions’ (T’s) are T9 and T13, and the ‘Avoid Note’ (AN) is AN11. The symbols next to the name of each chord scale indicate the chord formed by the CT’s e.g., Ionian’s ‘maj7’ = a major seventh chord (C+E+G+B / 1 3 5 maj7). Whole-tone is unique because, depending upon which notes are understood as CT’s and T’s, it can form either a +7 (C+E+G#+Bb / 1 3 +5 -7) or 7b5 (C+E+Gb+Bb / 1 3 b5 -7) chord. Chord symbols will receive greater attention in the coming pages.

AN’s are ‘nonchord tones which are *a half step above* a chord tone’ (pp. 26) e.g., Ionian’s AN11 is a half step above 3. Although the root of Ionian, Lydian, and melodic minor is a CT, ‘it should represent an avoid note inasmuch as it is a half step above the major 7th’ (pp. 27). Consequently, it is typical to find the alternative 6th chords (e.g., C-E-G-A in Ionian and Lydian) where the root is in the melody. Except for Mixolydian’s AN11, half steps above ‘Chord Tones’ (pp. 17) are accepted in chord scales with dominant seventh CT’s ‘because of their inherent instability’ (pp. 26). This is demonstrated by Tb9 in the altered and symmetric dominant chord scales.

Nettles and Graf present Dorian’s sixth degree as both a T and AN, deriving the latter from the tritone interval – ‘the basis for dominant sound and function’ – between the third and sixth degrees. Additionally, although they acknowledge that Mixolydian 7sus4 ‘may be heard as either a dominant or subdominant sound’ (pp. 38), they presumably present the third degree as an AN due to the tritone with -7. This may also stem from T3's potential challenge to sus4 as a CT, which is not a problem if sus4 is sufficiently well-defined in the lower register.

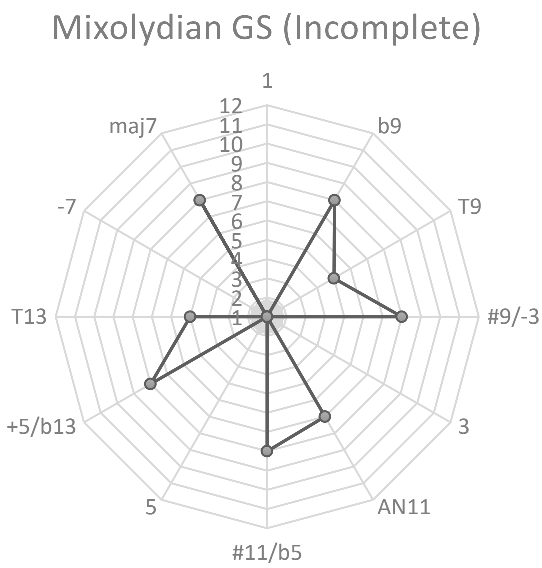
Unlike the 'half step above a chord tone' (pp. 26) rule, the occurrence of tritones in non-dominant chord scales does not seem an appropriate gauge of AN's for two reasons. Firstly, there are exceptions e.g., Lydian's T#11 forms a tritone with the fundamental, Aeolian's T9 forms a tritone with ANb13 etc. Secondly, subdominant / dominant / tonic functionality is not inherent to the chord scales e.g., the use of a tritone does not automatically result in a dominant function that demands resolution. This will also receive greater attention in the coming pages.

Perhaps aware of these reasons, Nettles and Graf caveat their Dorian indecision by stating that attitudes towards AN's are 'slowly changing, especially in jazz situations' (pp. 27). As a result, only the half step rule will be used to determine AN's in this research e.g., Dorian contains T13, Mixolydian 7sus4 contains T3, and there will be additional examples later in the text. This decision will be further substantiated during the spectral analysis.

Nettles and Graf are clear with the CT/T/AN organisation for all chord scales except for altered. It will be comprehensively explained in Chapter 4 how Mixolydian's '9^{th}, 5^{th}, and/or the 13^{th} may be altered to b9 and #9, b5, and/or b13' (pp. 45). The altered chord scale is so-named because it contains all these alterations. Although Nettles and Graf state that altered 'has no avoid notes' (pp. 46), they do not distinguish between the CT's and T's.

1, 3, and -7 are CT's because altered is related to Mixolydian. Furthermore, b9 and #9 are T's due to their status as such in symmetric dominant, another chord scale with dominant seventh CT's. As they are grouped with b9 and #9 as alterations, b5 and b13 may also be judged to represent T's. It is fair to question this given the b5 and +5 (equivalent to b13) CT's in the 7b5 and +7 versions of whole-tone, respectively. However, Tb5 will receive further justification during the spectral analysis and Tb13 will in Chapter 4. These tones are also represented as T's in Mark Levine's *The Jazz Theory Book* (1995, pp. 70) and Ted Pease's *Jazz Composition: Theory and Practice* (2003, pp. xv).

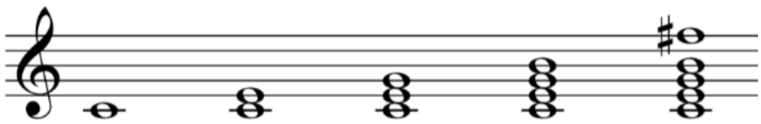
Using the CT/T/AN qualities as a *g* value framework, Example 3.4b shows an incomplete Mixolydian GS in which: the CT's (1 3 5 -7), as the four gravi-tones most closely related to *g*1, occupy the values *g*1-*g*4; the T's (T9 and T13), as the two gravi-tones that are further from *g*1 than the CT's but closer than the AN, occupy *g*5-*g*6; the lone AN (AN11) occupies *g*7; and the five gravi-tones that are unrepresented in the chord scale (b9, #9/-3, #11/b5, +5/b13, maj7) can be understood as representing the most distant values, *g*8-*g*12. The twelve gravi-tones are positioned like numbers on a clockface, and their *g* values are shown by a dot positioned between the centre of the chart (*g*1) and the outer-line (*g*12).



Example 3.4b: An incomplete Mixolydian GS using the CST qualities as a *g* value framework: CT's = *g*1, T's = *g*5 =, AN = *g*7, unrepresented = *g*8.

Because the *g* values of the individual gravi-tones (other than the AN) are yet to be ascertained, each level has been attributed a single value: CT's = *g*1, T's = *g*5 =, AN = *g*7, unrepresented = *g*8. Whilst these level-representative values can be mapped onto some of the other chord scales (including Ionian, Mixolydian, Aeolian, and Locrian), differing numbers of gravi-tones per category mean that these values are not one-size-fits-all e.g., Lydian has no AN so the T's would occupy *g*5-*g*7.

In addition to offering a *g* value framework for the chord scales in Example 3.4a, CST shows how these chord scale GS' are attributed by the first quality of GSF: present tone(s). To illustrate this, Example 3.4c shows five independent structures of present tones.



Example 3.4c: Five independent structures of present tones.

The single tone (C) could correspond to any of the chord scale GS' in Example 3.4a. For the second structure (C+E / 1 3), the number of chord scale GS' options remain significant but are reduced considerably: Ionian, Lydian, Mixolydian, Mixolydian 7sus4, Lydian b7, altered, whole-tone, and symmetric dominant. There are two fewer options for the third structure (C+E+G / 1 3 5) because the G / 5 does not fit in altered or whole-tone. Similarly, the presence of B in the fourth structure (C+E+G+B / 1 3 5 maj7) reduces the options to Ionian and Lydian. Lastly, with the presence of the F# (T#11) in the fifth structure, only Lydian remains as a matching chord scale GS.

In summary, CST has provided a *g* value framework for the chord scales shown in Example 3.4a, yielded chord scale GS options for structures two to four in Example 3.4c, and determined the Lydian chord scale GS for structure five. However, it is yet to be clarified: (1) how to practically account for the gravi-tones outside of the chord scale (*g*8-*g*12 for most), (2) how specific GS' can be attributed to the first four major chord structures of Example 3.4c, and (3) how precise *g* values can be attributed within the qualities of each chord scale.

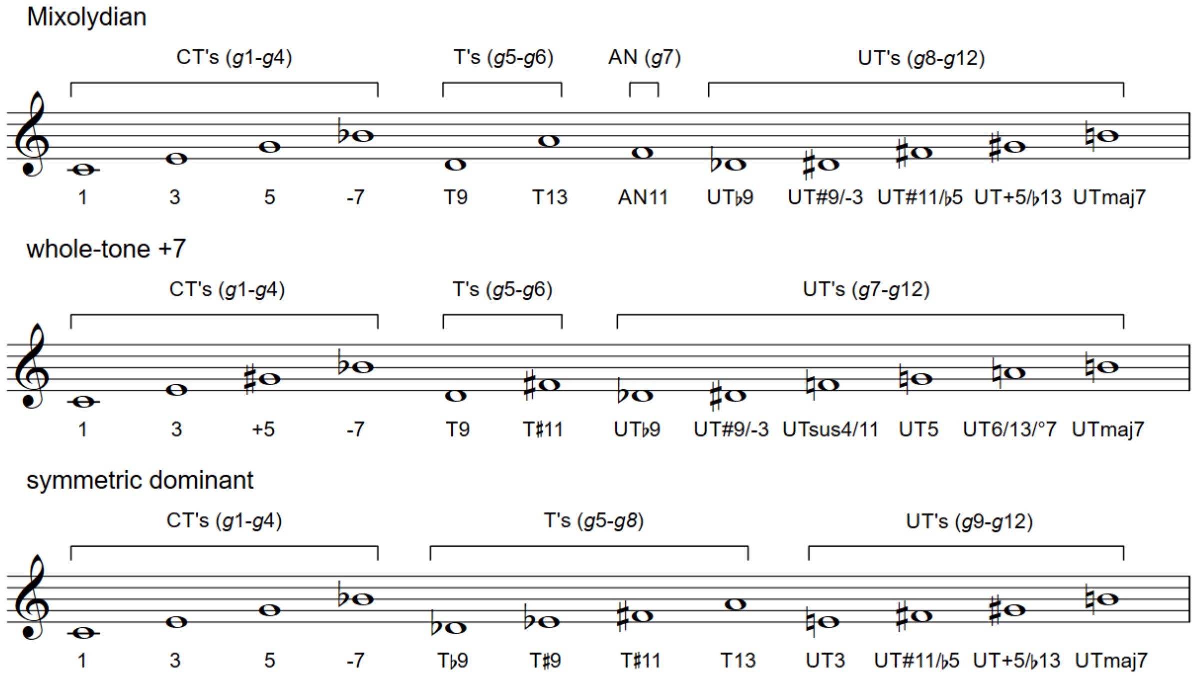
<u>3.5: Upper Tensions</u>

As summarised at the end of the previous section, CST does not account for the gravi-tones that are outside of the individual chord scales e.g., for the Mixolydian chord scale, these include b9, #9/-3, #11/b5, +5/b13, and maj7. These unrepresented gravi-tones can vary in number depending upon the number of gravi-tones that are included in a chord scale. Most of the chord scales in Example 3.4a contain seven gravi-tones (such as Dorian), leaving five unrepresented gravi-tones (*g*8-*g*12). However, whole-tone only contains six gravi-tones, leaving six unrepresented (*g*7-*g*12), and the two symmetric scales each contain eight gravi-tones, leaving only four unrepresented (*g*9-*g*12).

The composer Miroslav Spasov offers a means of representing and using these gravi-tones by classifying them as 'upper tensions' (or 'UT's') (Pejovski, 2021 – unpublished manuscript). The nature and application of the UT's is explained in the following extract. Note: whereas this thesis uses 'Chord Tones' (Nettles & Graf, 1997, pp. 17) or CT's to label the gravi-tones assembling the seventh chord, the following extract uses 'chord sound'.

> the composer can select numerous variations of the tripartite vertical structure in the voicing – chord sound, tension notes, and the upper tension notes. By default, they are arranged in bottom-up order, meaning the chord sound in the relatively lower register, the tension notes in the middle, and the upper tension notes in the higher register. With this organization, the chord sound combined with the tension notes will dominate and will define clearly the macro-progression, while the upper tension notes will bring some additional nuance to the sound, extra tension, new character, etc. […] as the tension notes can be combined or mutually substituted by notes from the chord sound in the same register, so it is always possible for the upper tension notes to be intertwined with both the tension and the chord sound notes.
>
> (Pejovski, 2021 – unpublished manuscript)

Example 3.5a shows the Mixolydian, whole-tone, and symmetric dominant chord scales organised into the CT/T/AN/UT qualities. Each quality is labelled with the corresponding *g* values. As shown in Example 3.4a, the CT's of whole-tone can form either a 7b5 or +7 chord. Example 3.5a shows the +7 version. Neither the Pejovski text or CST (Nettles and Graf, 1997) offer a solution for how the UT's can be represented as scale degrees. In this work, each UT will be mapped to all scale degree numbers available for their pitch class. In C whole-tone +7, for example, A will be represented as UT6/13/°7. In C symmetric dominant, F will be represented as UTsus4/11.



Example 3.5a: The CT/T/AN/UT qualities of Mixolydian, whole-tone +7, and symmetric dominant.

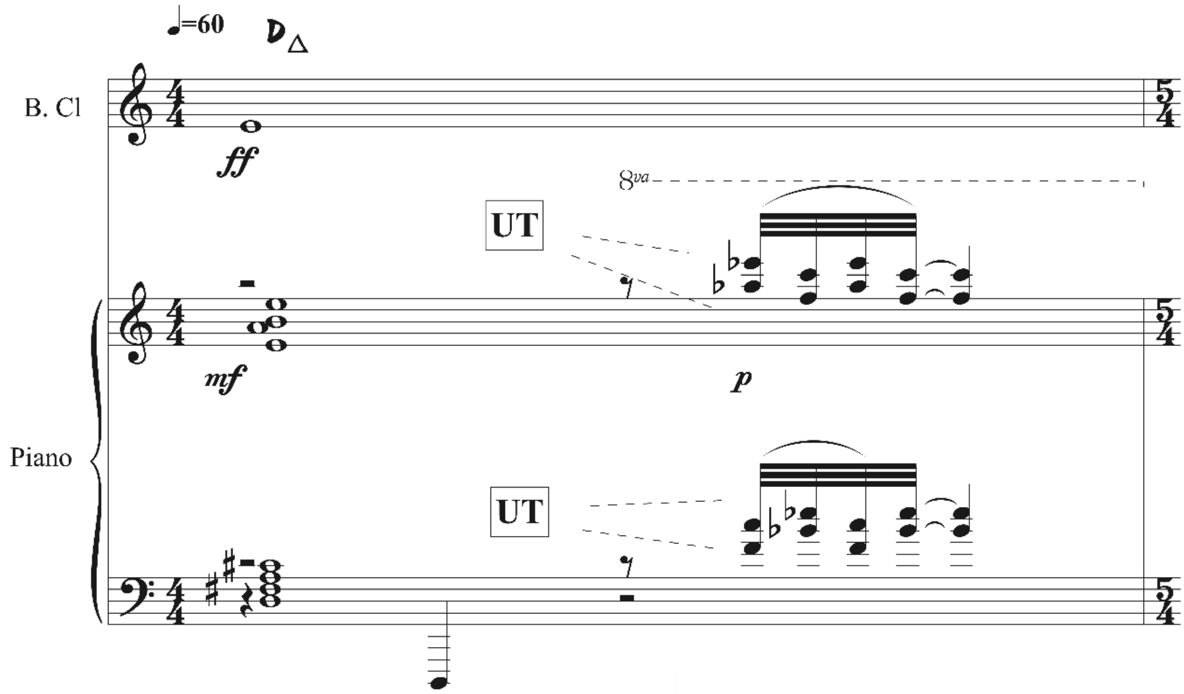
As detailed by the extract, the registral position of the UT's relative to the other gravi-tones is essential to their quality. If they are positioned too low in the voicing, then they can undermine and assume the role of gravi-tones intended as CT's or T's. For example, if Mixolydian's UT#9/-3 were sounded in the absence of the 3 CT, then -3 could become a CT and completely change the chord scale GS. Likewise, if F# (UT#11/b5) were played instead of F (AN11), then F# could change the GS to Lydian b7 and assume the role of T#11.

Due to the harmonically unstable nature of the AN's, the Pejovski text groups them together with the UT's. However, this harmonic instability is not derived only from distance. The inclusion of AN's in a harmonic structure seemingly makes GSF question its output (the attributed GS), leading to a friction in the processing that may be likened to dissonance or instability.

This effect is more prominent with some AN's than others. For example, whereas it is particularly noticeable with AN11 in Ionian, it is less-so with Aeolian's ANb13. The separability of the friction and distance is evident from the greater melodic consonance of the AN's than the UT's. This is because the AN's belong to the chord scales whereas the UT's exist 'outside'. Consequently, the AN's will be treated as closer than the UT's.

The UT's can be considered as approaching the ideas of the spectral movement and electroacoustic music discourse. To quote Dennis Smalley's *Spectromorphology: Explaining Sound-Shapes* (1997), the inclusion of the UT's meets the spectral criterion of moving away from 'individually perceived pitches' (pp. 118) and thus require expanding the 'terminology of qualitative description in order to deal more comprehensively with aspects of spectral space' (pp. 119) e.g., how 'bright, dull, hollow, thin, intense, and so on' that a given structure containing UT's may sound.

Example 3.5b is an excerpt from Miroslav Spasov's *Dolce Armonia* (2019) and shows a D Lydian GS with two UT's engaged. The gravi-tones with the semibreve duration are all CT's and T's. In ascending order, these include: (left hand of the piano) 1 (D), 3 (F#), 5 (A), maj7 (C#), (right hand) T9 (E), 5, T13 (B), T9, and (bass clarinet) T9. These, the low D crotchet, and other CT's and T's that are present in the hemi-demi-semi-quaver passage (including the Lydian confirming T#11 (G#)) provide a firm chord scale GS identity for the UT's that are interspersed amongst the hemi-demi-semi-quavers. In ascending order, these include: (left hand of the piano) UT+5/b13 (Bb), UTb9 (Eb), and (right hand) another UTb9.



Example 3.5b: An excerpt from Spasov's *Dolce Armonia* (2019).

It is also possible to identify UT's in jazz music. An interesting example can be found in the melody of *Cantaloupe Island* (Hancock, 1964). In the original recording, the cornetist Freddie Hubbard plays a C over the Db7 chord in all repetitions of the melody. This maj7 interval does not occur in any of the dominant seventh chord scales and it can therefore be classed as a UT. However, in two other performances where the melody is played by Wayne Shorter (2012) and Pat Metheny (2010) respectively, a Cb is played in place of the C as a conventional -7 interval (a CT). Both versions of this melodic excerpt are shown in Example 3.5c.

Example 3.5c: Two versions of a melodic excerpt from *Cantaloupe Island* (Hancock, 1964).

Whilst it cannot be proven without consulting the artists, Shorter's and Metheny's revision could indicate their awareness that the maj7 interval does not fit with conventional CST rules and that they have instead chosen to 'correct' it.

<u>3.6: Chord Symbols</u>

Now that the UT's have been introduced, it can be clarified that the chord symbols used in this research are largely consistent with the CST approach – as demonstrated in Example 3.4a e.g., maj7, +7, -7b5 etc. The steps involved in this approach are clearly outlined by Jonathan Feist's *Berklee Contemporary Music Notation* (2017, pp. 52) in Example 3.6a.

A chord symbol consists of up to five parts:

1. The chord root is indicated by a letter for the note name. The other information provided is in (usually) diatonic relationship to the given note.
2. The triad quality other than major is indicated with a suffix: minor (mi, min, –), augmented (aug, +), or diminished (dim, °). Major triads do not have suffixes indicating their quality; it is understood.
3. Whether there is a 6 or 7. The 6 and 7 are considered basic chord tones, rather than tensions (extensions). A major 7 chord will have a suffix, such as Maj7 or Ma7. This is an example of a logical incongruity with chord symbol notation; the quality suffix in this case refers to the 7, not the 3, as it does in all other cases. Without the "Maj," the 7 is a ♭7, not a diatonic 7.
4. Chord tensions 9, 11, and 13. At Berklee, we set tensions in parentheses. Usually. There is also the common shortcut to leave out the 7 and just use the tensions, such as C9 and C13.
5. More advanced structural information, such as specific bass notes, polychords, or upper-structure triads.

Example 3.6a: Feist's (2017, pp. 52) chord symbol instructions.

Steps one to three will be followed closely in this work. There are four exceptions where steps two (triad quality) and three (seventh) are reversed: the 7sus4 chord of Mixolydian 7sus4, the -7b5 chord of Locrian, the 7no5 chord of altered, and the 7b5 chord of whole-tone 7b5. Regarding step three, the common use of 6 in the symbol is the reason it has been included in the scale degree numbering for the gravi-tones e.g., 6/13/°7.

For step four, in the interests of clearly representing the present tones, the 'common shortcut to leave out the 7 and just use the tensions' will not be taken. Moreover, in addition to the T's, the parentheses of step four will also house AN's and UT's. The order of the T's, AN's, and UT's in the symbol will reflect their relative registral position in the voicing, from low to high. For example, the symbol Cmaj7(9/<u>11</u>**/+5/b13**) shows T9 as the lowest of the gravi-tones (not counting CT's), AN11 as higher, and UT+5/b13 as the highest.

To highlight these categories within the symbol, AN's are underlined, and UT's are printed in bold. The relative position of the CT's, as they are strong in any octave of the voicing, is not tracked in the same way. These alterations to step four do not affect the fifth step of Feist's method (e.g., Cmaj7(9/<u>11</u>/**+5/b13**)/G) but the gravi-tone listed first (C) will always be the fundamental tone / g*1*.

3.7: Spectral Analysis: Introduction and Data

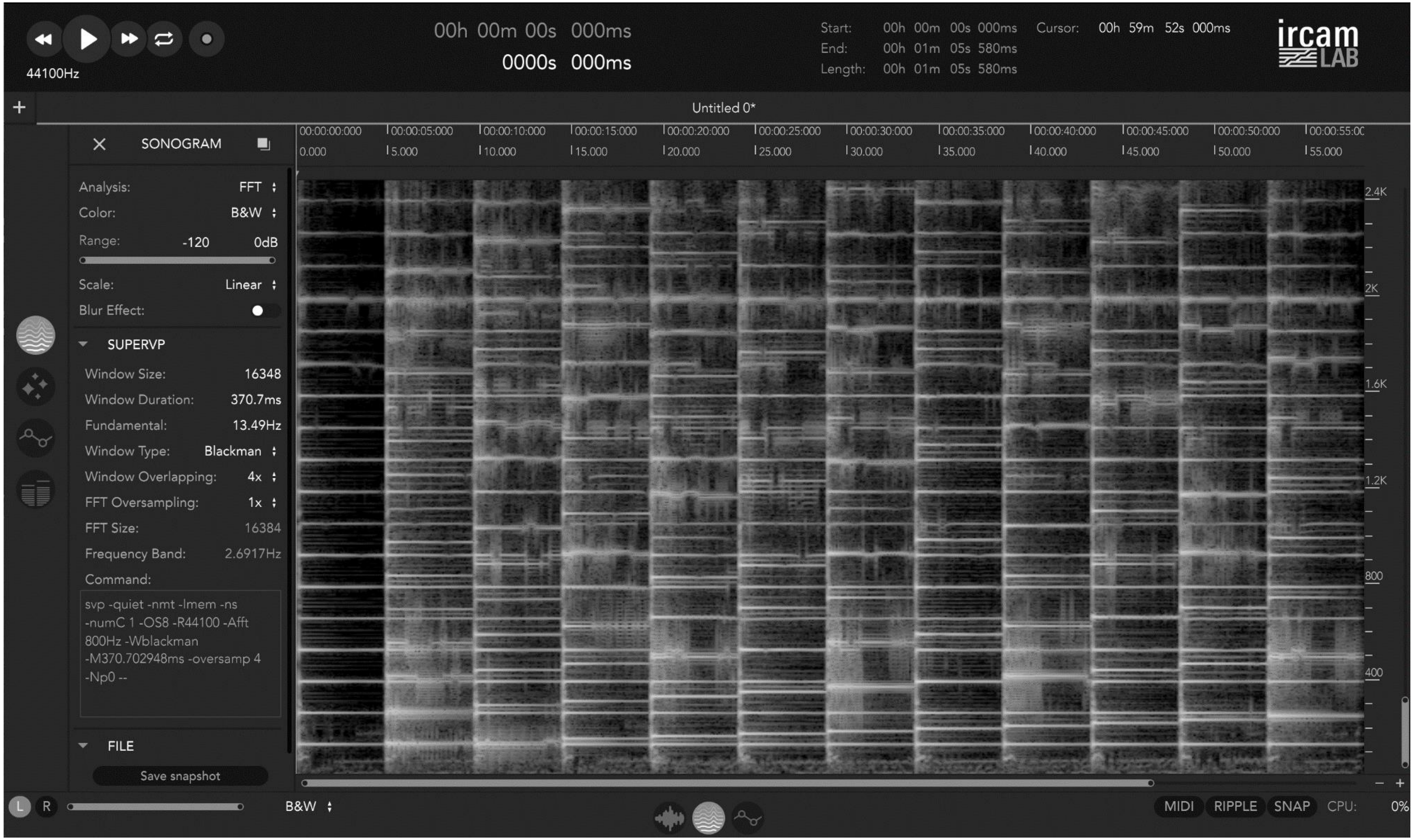
At the end of section '3.4: The Chord Scale Theory', it was stated that three factors remained to be clarified: (1) how to practically account for the gravi-tones outside of the chord scale (*g*8-*g*12 for most), (2) how specific GS' can be attributed to the first four present tone structures of Example 3.4c (single tone, major third, major triad, major seventh chord), and (3) how precise *g* values can be attributed within the qualities of each chord scale.

The first has been resolved by the integration of Miroslav Spasov's 'upper tensions' ('UT's') (Pejovski, 2021 – unpublished manuscript). Solutions for the second and third factors can be derived from the second quality of GSF: the harmonic spectra of present tone(s). This will also bring acoustic justification for the *g* value framework offered by the CT/T/AN/UT qualities of CST.

The spectral analysis was carried out using *TS2* (IrcamLAB, 2021), one of the most sophisticated software applications for analysing spectra. *TS2* processes an accurate real-time sonogram display. It features 'Short-time Fourier transform' (STFT), used to determine the sinusoidal frequency and phase content of local sections of a signal as it changes over time. STFT divides the signal into shorter segments of equal length and then computes the Fourier transform separately on each shorter segment. Then, it plots the changing spectra as a spectrogram function of time.

The analysis took into consideration frequencies (Hz), MIDI notes as frequency equivalents, and the decibel level (dB) of each frequency. Analysis settings for the STFT were as follows: window size = 16384 samples, window type: ‘Blackman’, frequency ‘bins’ (channels) ranging 50-4186Hz, and a standard digital dB scale between 0 (maximum) and -120 (the lowest measurable level in digital systems).

Various Chord Tone (CT) configurations were analysed for every chord scale GS. To minimise dynamic variation in the ‘performance’, the CT configurations were played automatically by a Steinway Grand Piano in *Finale* (MakeMusic, 2020). All were played ‘forte’, at a tempo of 60bpm (each lasting four seconds), and with a fundamental of C3 (MIDI number 48, 130.81Hz). Measurements were usually taken between one and two seconds following the attack of the sound. Example 3.7a shows the sonogram for the first set of CT configurations: the single tone (left) followed by a series of dyads.



Example 3.7a: The sonogram generated by *TS2* (IrcamLAB, 2021) for the first set of CT configuration: the single tone (left) followed by a series of dyads.

The analysis of these sonograms resulted in the data tables of Example 3.7c (see following pages). In each of these tables, the CT configurations are shown at the bottom as ‘PT’s’ (present tones). The PT’s in the first table of Example 3.7c are the single tone and dyads (as in the sonogram of Example 3.7a), the second table shows triads, and the third table shows seventh chords. In the column above each PT combination, the harmonic spectra are shown from low to high with the pitch class and octave number of each partial. The octave numbering uses Scientific Pitch Notation, as shown in Example 3.7b.

Example 3.7b: Scientific Pitch Notation.

It is well-documented that the tuning ratios of the harmonics do not correspond with equal temperament. As stated by Paul Hindemith, ‘except for the octave, not a single one’ of the intervals in twelve-tone equal temperament ‘is exactly equal to a pure interval of the overtone series’ (1941, pp. 28). Each of the partials in Example 3.7c are expressed as their nearest equally-tempered pitch frequency. Moreover, because all intervals from C3 in the PT combinations of Example 3.7c are equally-tempered, the spectra are also affected by the tempering. As a result, except for the spectra of the single tone (C3), the data of Example 3.7c is specific to the equal-tempered system.

Each harmonic is accompanied by a number that indicates its individual dB level. Whilst the dB levels will be occasionally cited in the analysis, they have also been allocated into four tiers of ‘presence’ for analytical convenience and to reflect the experiential significance of each partial. Presence can be considered as an ‘esthesic dimension’ (Nattiez, 1990, pp. 12) equivalent to the ‘neutral level’ dB level of the partials.

Indicated next to the dB level of each partial, the tiers include: strong presence (SP), consisting of dB levels between -20 and -39; medium presence (MP), dB levels between -40 and -49; weak presence (WP), dB levels between -50 and -59; and no presence (NP), dB levels including -60dB and below. Partials belonging to the NP tier are perhaps imperceptible and are discussed largely for theoretical purposes. To accessibly reflect the tiers of presence, each partial’s cell has been colour-coded: SP = white, MP = light grey, WP = dark grey, and NP = black.

Example 3.7c: The harmonic spectra of present tone(s) (PT's). The PT's are various Chord Tone (CT) configurations for each GS: the single tone and dyads (first table), triads (second table), and seventh chords (third table). In each PT combination's column, the spectra are shown from low to high with the pitch class and octave number of each partial. Each harmonic is accompanied by a number that indicates its individual decibel (dB) level. These levels are organised into four tiers of presence: -20 to -39dB = strong presence (SP), -40 to -49dB = medium presence (MP), -50 to -59dB = weak presence (WP), and -60dB and below = no presence (NP). To accessibly reflect the tiers of presence, each partial's cell has been colour-coded: SP = white, MP = light grey, WP = dark grey, and NP = black.

HARMONIC SPECTRA	D#/Eb7 -75/NP									
	D7 -80/NP	Db7 -54/WP	D#/Eb7 -55/WP							
	Db7 -66/NP	B6 -46/MP	Db7 -55/WP							B6 -45/MP
	C7 -70/NP	Bb6 -46/MP	B6 -45/MP							Bb6 -47/MP
	B6 -53/WP	A6 -48/MP	Bb6 -46/MP	B6 -45/MP						A6 -55/WP
	Bb6 -54/WP	G6 -42/MP	A6 -53/WP	Bb6 -46/MP						G6 -45/MP
	A6 -54/WP -60/NP	F6 -46/MP	G#/Ab6 -50/WP	F#/Gb6 -50/WP						E6 -48/MP
	G#/Ab6 -54/WP -73/NP	E6 -53/WP	G6 -45/MP	E6 -53/WP	B6 -47/MP	B6 -42/MP	C6 -32/SP	E6 -44/MP	Bb6 -47/MP	D#/Eb6 -43/MP
	G6 -50/WP	D6 -46/MP	E6 -47/MP	D6 -47/MP	Bb6 -49/MP	Bb6 -46/MP	G#/Ab5 -31/SP	D6 -43/MP	F#/Gb6 -51/WP	D6 -49/MP
	F#/Gb6 -57/WP	Db6 -45/MP	D6 -42/MP	Bb5 -43/MP	E6 -41/MP	G6 -43/MP	G5 -33/SP	Db6 -36/SP	E6 -47/MP	B5 -32/SP
	E6 -52/WP	Bb5 -42/MP	B5 -42/MP	A5 -39/SP	Bb5 -35/SP	D6 -47/MP	D#/Eb5 -34/SP	Bb5 -44/MP	D6 -42/MP	Bb5 -43/MP
	D6 -50/WP	G5 -40/MP	G#/Ab5 -33/SP	G5 -40/MP	G5 -36/SP	B5 -38/SP	C5 -32/SP	A5 -36/SP	Bb5 -40/MP	G5 -38/SP
	C6 -64/NP	D#/Eb5 -50/WP	G5 -35/SP	F5 -39/SP	F#/Gb5 -34/SP	Bb5 -42/MP	Bb4 -54/WP	G5 -35/SP	G5 -37/SP	F#/Gb5 -39/SP
	Bb5 -47/MP	C5 -42/MP	E5 -31/SP	E5 -51/WP	Db5 -45/MP	G5 -37/SP	A4 -39/SP	E5 -35/SP	F5 -35/SP	C5 -35/SP
	G5 -43/MP	Bb4 -39/SP	B4 -48/MP	C5 -33/SP	G4 -41/MP	D5 -35/SP	G#/Ab4 -24/SP	C5 -32/SP	C5 -35/SP	B4 -41/MP
	E5 -51/WP	G4 -37/SP	G4 -31/SP	G4 -34/SP	F#/Gb4 -28/SP	C5 -36/SP	G4 -37/SP	A4 -26/SP	Bb4 -32/SP	G4 -33/SP
	C5 -41/MP	D#/Eb4 -41/SP	E4 -25/SP	F4 -27/SP	F4 -39/SP	G4 -26/SP	F#/Gb4 -56/WP	G4 -31/SP	G4 -32/SP	C4 -37/SP
	G4 -37/SP	C4 -38/SP	C4 -32SP	C4 -36/SP	C4 -33/SP	C4 -34/SP	C4 -30/SP	C4 -32/SP	C4 -34/SP	B3 -31/SP
	C4 -38/SP	D#/Eb3 -39/SP	E3 -31/SP	F3 -30/SP	F#/Gb3 -29/SP	G3 -29/SP	G#/Ab3 -29/SP	A3 -30/SP	Bb3 -31/SP	Bb3 -50/WP
	C3 -37/SP	C3 -36/SP	C3 -31/SP	C3 -33/SP	C3 -31/SP	C3 -32/SP	C3 -29/SP	C3 -30/SP	C3 -31/SP	C3 -32/SP
PT('s)	C3	C3+Eb3	C3+E3	C3+F3	C3+Gb3	C3+G3	C3+G#3	C3+A3	C3+Bb3	C3+B3
TIME	1500-2000ms									

HARMONIC SPECTRA	F#/Gb7 -79/NP	F#/Gb7 -74/NP	G7 -79/NP	G#/Ab7 -88/NP		F#/Gb7 -84/NP	
	D#/Eb7 -87/NP	E7 -86/NP	E7 -82/NP	F#/Gb7 -87/NP		D#/Eb7 -82/NP	Db6 -47/MP
	Db7 -86/NP	Db7 -86/NP	Db7 -81/NP	Db7 -79/NP	D6 -46/MP	Db7 -84/NP	Bb5 -47/MP
	B5 -44/MP	Db6 -43/MP	Bb5 -39/SP	D#/Eb6 -41/MP	Bb5 -44/MP	C6 -42/MP	G#/Ab5 -41/MP
	Bb5 -47/MP	B5 -43/MP	G5 -40/MP	B5 -45/MP	G#/Ab5 -44/MP	G#/Ab5 -38/SP	G5 -42/MP
	G#/Ab5 -42/MP	Bb5 -43/MP	F#/Gb5 -39/SP	Bb5 -46/MP	G5 -44/MP	G5 -40/MP	F#/Gb5 -39/SP
	G5 -42/MP	G5 -41/MP	D#/Eb5 -41/MP	A5 -42/MP	F5 -37/SP	E5 -37/SP	E5 -39/SP
	E5 -42/MP	D#/Eb5 -42/MP	Db5 -39/SP	G5 -41/MP	E5 -40/MP	D#/Eb5 -39/SP	Db5 -33/SP
	D5 -37/SP	D5 -40/MP	C5 -38/SP	F5 -42/MP	C5 -42/MP	C5 -39/SP	C5 -42/SP
	C5 -44/MP	C5 -39/SP	Bb4 -36/SP	D5 -37/SP	B4 -37/SP	B4 -40/MP	B4 -34/SP
	B4 -40/MP	Bb4 -37/SP	G4 -35/SP	C5 -35/SP	Bb4 -32/SP	G#/Ab4 -31/SP	G4 -37/SP
	G4 -34/SP	G4 -34/SP	F#/Gb4 -29/SP	G4 -32/SP	G4 -37/SP	G4 -35/SP	F#/Gb4 -29/SP
	E4 -31/SP	D#/Eb4 -40/MP	D#/Eb4 -39/SP	F4 -31/SP	E4 -30/SP	E4 -29/SP	E4 -28/SP
	C4 -40/MP	C4 -37/SP	C4 -32/SP	C4 -39/SP	C4 -39/SP	C4 -37/SP	C4 -39/SP
	G3 -37/SP	G3 -34/SP	F#/Gb3 -32/SP	G3 -35/SP	Bb3 -36/SP	G#/Ab3 -34/SP	F#/Gb3 -33/SP
	E3 -34/SP	D#/Eb3 -38/SP	D#/Eb3 -37/SP	F3 -33/SP	E3 -32/SP	E3 -31/SP	E3 -31/SP
	C3 -39/SP	C3 -35/SP	C3 -35/SP	C3 -37/SP	C3 -37/SP	C3 -35/SP	C3 -36/SP
PT's	C3+E3+G3	C3+Eb3+G3	C3+Eb3+Gb3	C3+F3+G3	C3+E3+Bb3	C3+E3+G#3	C3+E3+Gb3
TIME	1000ms						

HARMONIC SPECTRA					D6 -49/MP				D6 -46/MP
	E6 -58/WP	E6 -53/WP		D6 -48/MP	Db6 -47/MP	D6 -50/WP			Bb5 -43/MP
	D#/Eb6 -48/MP	Db6 -51/WP	D6 -49/MP	Db6 -47/MP	Bb5 -42/MP	Db6 -47/MP	D#/Eb6 -53/WP	Bb5 -45/MP	G#/Ab5 -39/SP
	B5 -39/SP	Bb5 -43/MP	Db6 -47/MP	Bb5 -43/MP	A5 -44/MP	B5 -38/SP	D6 -52/WP	G#Ab5 -40/MP	G5 -42/MP
	Bb5 -46/MP	G#/Ab5 -43/MP	B5 -44/MP	G5 -44/MP	F#/Gb5 -42/MP	Bb5 -46/MP	B5 -45/MP	G5 -43/MP	F#/Gb5 -40/MP
	G#/Ab5 -40/MP	G5 -43/MP	Bb5 -44/MP	F#/Gb5 -43/MP	E5 -38/SP	G5 -42/MP	Bb5 -46/MP	F5 -39/SP	F5 -39/SP
	G5 -40/MP	F5 -39/SP	G5 -43/MP	F5 -38/SP	D#/Eb5 -45/MP	F#/Gb5 -42/MP	A5 -43/MP	E5 -39/SP	E5 -38/SP
	F#/Gb5 -43/MP	E5 -41/MP	F5 -39/SP	D#/Eb5 -45/MP	Db5 -40/MP	D#/Eb5 -47/MP	G5 -43/MP	D#/Eb5 -41/MP	Db5 -41/MP
	E5 -35/SP	D5 -39/SP	D#/Eb5 -43/MP	Db5 -39/SP	C5 -41/MP	D5 -37/SP	F5 -45/MP	C5 -41/MP	C5 -39/SP
	D5 -37/SP	C5 -42/MP	D5 -39/SP	C5 -41/MP	Bb4 -39/SP	C5 -42/MP	D5 -39/SP	B4 -42/MP	B4 -41/MP
	C5 -41/MP	B4 -41/MP	C5 -42/MP	Bb4 -34/SP	A4 -34/SP	B4 -41/MP	C5 -39/SP	Bb4 -33/SP	Bb4 -32/SP
	B4 -34/SP	Bb4 -33/SP	Bb4 -34/SP	G4 -39/SP	G4 -38/SP	Bb4 -39/SP	Bb4 -33/SP	G#/Ab4 -32/SP	G4 -36/SP
	G4 -35/SP	G4 -34/SP	G4 -33/SP	F#/Gb4 -34/SP	F#/Gb4 -31/SP	G4 -32/SP	G4 -33/SP	G4 -37/SP	F#/Gb4 -31/SP
	E4 -31/SP	E4 -33/SP	D#/Eb4 -43/MP	D#/Eb4 -42/MP	D#/Eb4 -42/MP	D#/Eb4 -42/MP	F4 -32/SP	E4 -31/SP	E4 -30/SP
	C4 -40/MP	C4 -40/MP	C4 -40/MP	C4 -39/SP	C4 -39/SP	C4 -39/SP	C4 -40/MP	C4 -39/SP	C4 -38/SP
	B3 -37/SP	Bb3 -38/SP	Bb3 -39/SP	Bb3 -39/SP	A3 -37/SP	B3 -36/SP	Bb3 -38/SP	Bb3 -37/SP	Bb3 -36/SP
	G3 -37/SP	G3 -37/SP	G3 -38/SP	F#/Gb3 -35/SP	F#/Gb3 -35/SP	G3 -35/SP	G3 -36/SP	G#/Ab3 -36/SP	F#Gb3 -34/SP
	E3 -38/SP	E3 -35/SP	D#/Eb3 -39/SP	D#/Eb3 -39/SP	D#/Eb3 -40/MP	D#/Eb3 -40/MP	F3 -35/SP	E3 -33/SP	E3 -32/SP
	C3 -38/SP	C3 -39/SP	C3 -38/SP	C3 -37/SP	C3 -37/SP	C3 -38/SP	C3 -38/SP	C3 -37/SP	C3 -36/SP
PT's	C3+E3+ G3+B3	C3+E3+ G3+Bb3	C3+Eb3+ G3+Bb3	C3+Eb3+ Gb3+Bb3	C3+Eb3+ Gb3+A3	C3+Eb3+ G3+B3	C3+F3+ G3+Bb3	C3+E3+ G#3+Bb3	C3+E3+ Gb3+Bb3
TIME	1000ms								

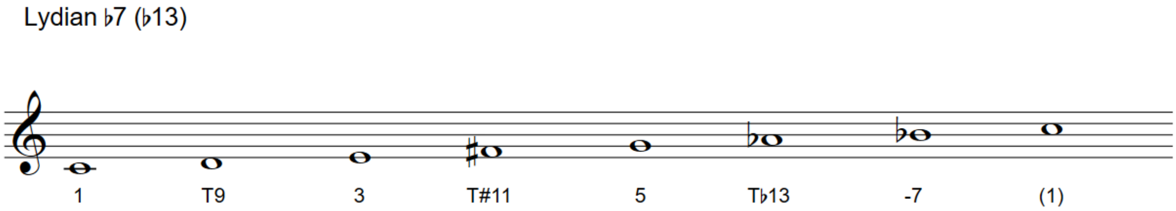
3.8: Spectral Analysis: GSF for the Single Tone

The five structures of present tones shown in Example 3.4c were a single tone (C), a major third interval (C+E), a major triad (C+E+G), a major seventh chord (C+E+G+B), and a major seventh chord with T#11 (C+E+G+B+F#). The paragraph following Example 3.4c analysed how GS' may be attributed to each structure using the present tone(s) quality of Gravi-Tone Series Filtering. It was explained that the final structure must inhabit a Lydian GS because the combination of tones does not occur in any other chord scale. It was also explained that, because the other four structures of present tones can occur in multiple chord scales, their GS' are indeterminate.

Consulting the spectra of structures one to four can help to determine the GS', and this section will focus on the single tone. The order of tones in the harmonic series (omitting repetitions) is as follows: C (fundamental / 1^{st} harmonic), G (3^{rd} harmonic), E (5^{th}), Bb (7^{th}), D (9^{th}), F#/Gb (11^{th}), G#/Ab (13^{th}), B (15^{th}), C#/Db (17^{th}), D#/Eb (19^{th}), F (21^{st}), and A (27^{th}). It is generally understood that each harmonic has progressively less presence than the last, not accounting for the timbre of specific instruments.

Using this understanding to derive a GS, the 'runner-up' presence of G suggests that the GS should contain scale degree 5 as a CT – ruling out altered, Locrian, whole-tone, and symmetric diminished. The 'bronze medal' presence of E (scale degree 3) completes the major triad and thus reduces the GS options to Ionian, Lydian, Mixolydian, Lydian b7, and symmetric dominant. Out of the podium positions, the Bb suggests a GS with scale degree -7 as a CT. This completes a dominant seventh chord, thus removing Ionian and Lydian as options. The removal of Ionian is significant because it confirms that its tonal dominion is not based solely on natural harmonics.

With the CT's completed, the tones that follow in the harmonic series can be recognised as T's. The first to occur, D (T9), occurs in Mixolydian and Lydian b7 but not symmetric dominant. Next, F#/Gb (T#11) occurs in Lydian b7 but not Mixolydian. Problematically, however, G#/Ab is absent from Lydian b7. Instead, this collection of tones assembles a Lydian b7 (b13) chord scale, as shown in Example 3.8a.



Example 3.8a: Lydian b7 (b13) chord scale.

Although G#/Ab fulfils the AN requirement of being a half step above a CT, the 'inherent instability' (Nettles and Graf, 1997, pp. 26) of dominant seventh CT's means that it is Tb13 instead. The tones following G#/Ab in the harmonic series represent the UT's of Lydian b7 (b13): B (UTmaj7), C#/Db (UTb9), D#/Eb (UT#9/-3), F (UTsus4/11), and A (UT6/13/°7). Additionally, it was argued in section '3.4: The Chord Scale Theory' that tritone intervals are a less appropriate means of deriving AN's than half steps above CT's. This is further substantiated by the later occurrence of Db (17th harmonic) than F# (11th) in the harmonic series.

The spectral content of the single tone (C3 in the first table of Example 3.7c) acquired via *TS2* (IRCAM, 2021) leads to a slightly different GS than the harmonic series. Fundamentally, the data shows that the order of tones in the harmonic series is not 1:1 with their relative presence. In correlation with their order in the harmonic series, C and G have the strongest presence. C has a SP in the third and fourth octaves, a MP in the fifth, and NP in the sixth and seventh. G, on the other hand, has a slightly weaker presence with a SP in the fourth octave, MP in the fifth octave, and WP in the sixth.

However, whereas E occurs before Bb in the harmonic series, their presence in the spectra of C3 is broadly the same. Although Bb occurs with a weak MP and E occurs with a strong WP in the fifth octave, E has a marginally stronger WP than Bb in the sixth octave. Nevertheless, both the order of the harmonic series and the spectra of C3 show that the CT's form a dominant seventh chord. It is with the T's and UT's that the spectra of C3 differs from the order of the harmonic series.

In correlation with the harmonic series, the tone with the next strongest presence is D (T9), with a maximally strong WP (-50dB). However, B (the 15th harmonic) is only 3dB quieter. With its potential as a maj7 CT, B brings a curious challenge to the Bb (-7) CT. However, the notably stronger presence of Bb suggests that it displaces B's potential as a CT, storing the latter as UTmaj7 – as in the Lydian b7 (b13) GS. It is also curious that B has a greater presence than F#/Gb and G#/Ab, the tones which precede it in the order of the harmonic series. This additional presence can be accredited to the strong presence of E, which can be recognised as a fundamental with B as its third harmonic.

Following D (T9) and B (UTmaj7), the tones with next strongest presence in the spectra of C3 are G#/Ab and A. These are the only tones in the tables of Example 3.7c to have two dB levels / presence tiers. At the onset, G#/Ab6 and A6 both sound with WP at -54dB. Although G#/Ab6 occurs as the 13th natural harmonic and A6 is only the 27th, the latter has garnered additional presence as the 3rd harmonic of D.

After 1000ms, G#/Ab6 and A6 both drop to NP with -73dB and -60dB, respectively. The significant drop in presence can be attributed to the clustering of minor second intervals between the higher partials. The initially equal presence of G#/Ab6 and A6 – and A6's victory after 1000ms – shows that the Lydian b7 (b13) GS derived from the order of tones in the harmonic series is not correct. A is T13 not UT6/13/°7, and G#/Ab is UT+5/b13 not Tb13. Further evidence of A's victory over G#/Ab can be found in the major scale (Ionian). Although it was noted above that it the major scale is not based only on natural harmonics, the presence of A (T13) rather than Ab (Tb13) may be an example of where it is.

Finally, F#/Gb is weaker than G#/Ab and A at their onset but stronger after 1000ms. Although F#/Gb precedes G#/Ab and A in the harmonic series, its marginally weaker presence at the onset may be explained by A's support as the 3rd harmonic of D and G#/Ab receiving support as the 5th harmonic of E. Regardless, the inclusion of F# (T#11) completes a Lydian b7 chord scale. This substantiates Lydian b7's other monikers as the 'acoustic' or 'overtone' scale.

Along with B (UTmaj7) and G#/Ab (UT+5/b13), the tones with the weakest presence are the UT's. Db (UTb9) and D#/Eb (UT#9/-3) both occur with NP and F (UTsus4/11) is the only tone that is absent from the spectra of C3. Also, like their order in the harmonic series, F#'s greater presence than Db brings additional weight to tritone intervals being a less suitable gauge of AN's than half steps above CT's.

Therefore, Lydian b7 is the omni-present GS for the single tone, as derived from the spectra of C3 with cross-analysis to the order of tones in the harmonic series. Moreover, the findings from both analytical routes brings acoustic credibility to the CT/T/AN/UT organisation of CST. The spectra of C3 and the harmonic series both illustrate the dominant seventh CT's of Lydian b7 as the tones with the strongest presence, followed by the T's, and generally followed by the UT's. The exceptions to the rule are UTmaj7 and UT+5/b13, which occur with stronger presence than the other UT’s but are displaced from potential CT and T roles by neighbouring tones.

Whilst Lydian b7 is the theoretically-appropriate GS for the single tone, the relative presence of the partials invites alternative assessments. It can be hypothesised that: the stronger the presence of a tone, the greater the chance that a listener will account for it when attributing a GS. Equally, the weaker the presence of a tone, the less likely that a listener will account for it. For example, if the NP tier is not accounted for, then the presence of A6 (T13) after 1000ms (-60dB) would not be accounted for. Consequently, the equal presence of G#/Ab6 (Tb13) and A6 (T13) at the onset may lead to the former challenging the latter, bringing the Lydian b7 (b13) GS as an option.

If the WP tier is not accounted for, however, this would remove D (T9), E (3), and F# (T#11) from the filtering process. Any chord scale containing scale degrees 1, 9, 5, and -7 then becomes an option for GSF: Dorian, Phrygian, Mixolydian, Mixolydian 7sus4, Aeolian, Lydian b7, and Lydian b7 (b13). Even more options result from only processing the SP’s, C (1) and G (5). Additionally, it should be considered that the presence tiers do not represent strict divisions of our perception. For example, a listener may perceive the SP’s, MP’s, and only the loudest WP’s, i.e., subtracting F# (T#11) from their GSF. The resulting pool of GS’ would include any chord scale containing scale degrees 1, 9, 3, 5, and -7: Mixolydian, Mixolydian 7sus4, and Lydian b7.

In addition to the relative presence of tones derived from their order in the harmonic series, the analysis of C3’s spectra demonstrated that specific tones gain presence by occurring in other harmonic series’ of lower partials. For example, although G#/Ab is the 13th natural harmonic, its status as the 5th harmonic of E gives it a stronger presence at the onset than F#/Gb, the 11th natural harmonic. Similarly, whilst B is only the 15th natural harmonic, its status as the 3rd harmonic of E gives B as a presence that is proximal to D, the 9th natural harmonic.

The considerable extra presence generated by these fifth intervals – the 3rd harmonic of alternative fundamentals – recalls George Russell's 'ladder of fifths' (2001, pp. 3) and Arnold Schoenberg's 'midpoint' theory (1978, pp. 23), both discussed in Chapter 2. Russell identified the fifth as 'the strongest harmonic interval' (pp. 3) and iterated it to produce the 'Lydian Chromatic Scale' (2001, pp. 12) with a 'close to distant relationship' (pp. 3) from the fundamental: C, G, D, A, E, B, F#, G#/Ab, D#/Eb, Bb, F, Db.

Although Russell's logic cannot be proven to be incorrect, it is not supported by the order of tones in the harmonic series or by their presence in the spectra of C3. In terms of order, the fifth is 'the strongest harmonic interval' because G is the first tone to follow C in the harmonic series. However, E and Bb occur before D, the next rung in the 'ladder of fifths'. Moreover, no less than six other tones occur between D and A (the next rung) in the harmonic series.

Compared to the presence of tones in the spectra of C3, the fifth is again shown as 'the strongest harmonic interval' by the runner-up presence of G. However, the presence of D (the next rung) is beaten by E and Bb, as with the order of tones in the harmonic series. Similarly, although A should have the fourth strongest presence according to the 'ladder of fifths', it is beaten by E, Bb, B, F#/Gb after 1000ms, and is equivalent to G#/Ab at the onset.

It can be concluded that Russell's conception of distance as a 'ladder of fifths' is arbitrary because it bears little resemblance to the natural order of harmonics or their 'actual' presence in the spectra of C3. Nevertheless, Russell comes close to the theoretically-appropriate GS for the single tone (Lydian b7) with his identification of Lydian as 'the natural child of the overtone series'.

The spectra of C3 may also be examined for evidence of Paul Hindemith's 'Series 1' (1941, pp. 56), as discussed in Chapter 2. From calculations based on the harmonic series, Hindemith produces the following 'diminishing degree of relationship' to a 'progenitor tone' (pp. 54) / fundamental: C, G, F, A, E, Eb, Ab, D, Bb, Db, B, Gb/F#. Whilst, like Russell, Hindemith correctly identifies G as the next closest tone, there is little correlation between 'Series 1' (pp. 56) and the Lydian b7 GS derived in the preceding pages.

The third tone in 'Series 1', F, belongs to the UT's of the Lydian b7 GS and is the only tone to have zero presence in the spectra of C3. The fourth tone, A, is the 27th natural harmonic and only gains a WP (dropping to NP after 1000ms) from its status as the 3rd harmonic of D. Furthermore, E shares the bronze medal of presence with Bb in the spectra of C3 but is preceded by F and A in 'Series 1'. These and other inconsistencies point to 'Series 1' not being supported by the spectra of the single tone.

To summarise, whilst the order of the harmonic series indicates Lydian b7 (b13) as the GS for the single tone, the 'actual' presence of C3's partials have revealed Lydian b7. This does not support either George Russell's 'Lydian Chromatic Scale' (2001, pp. 12) or Paul Hindemith's 'Series 1' (1941, pp. 56). However, whilst Lydian b7 is the theoretically-appropriate GS for the single tone, it is important to consider that a listener may not account for all tiers of presence (SP/MP/WP/NP). The subtraction of the NP tier may bring Lydian b7 (b13) as an option. If the WP tier is not accounted for, then no less than six GS' emerge as options. Practically speaking, therefore, the spectral content of the single tone contains potential for a multiplicity of GS'.

3.9: Spectral Analysis: GSF for Tempered PT Combinations

With GSF for the single tone resolved, three structures of present tones remain from Example 3.4c: a major third interval (C+E), a major triad (C+E+G), and a major seventh chord (C+E+G+B). As present tones (the first quality of GSF) are added to C3 and reduce the GS options, their harmonic spectra (the second quality of GSF) further reduce the GS options.

In the case of the major third interval, for example, the present tones reduce the options to Ionian, Lydian, Mixolydian, Mixolydian 7sus4, Lydian b7, altered, whole-tone, and symmetric dominant. However, the harmonic spectra of C3+E3 in Example 3.7c also offer G and G#/Ab as SP's. If the greater presence of G displaces G#/Ab as the fifth, then the complete major triad removes altered and whole-tone from the GS options.

The spectra of C3+E3 also show B as a MP across three octaves, arguably forming the equivalent of a SP in combination. This maj7 interval considerably reduces the GS options to only Ionian and Lydian. The D (T9) and A (T13) that the GS' share are both present in the spectra, but their distinctive gravi-tones (AN11 for Ionian, T#11 for Lydian) are not. Observing the spectra of the major triad (C3+E3+G3 in Example 3.7c) reaches the same Ionian / Lydian dead-end, with an F# (T#11) only occurring with NP at -79dB.

It is only when the present tones constitute a major seventh chord (C3+E3+G3+B3 in Example 3.7c) that Lydian is confirmed. F#5 occurs with a relatively strong MP (-43dB) as the 3rd harmonic of B3. However, as discussed with the single tone, it must be acknowledged that a listener may not account for all tiers of presence. Whilst Lydian may be the theoretically-appropriate GS, the MP of F# means that it is less likely to be accounted for than the SP's. In other words, it is possible that Ionian remains as an option.

Like the natural spectra of C3, the spectra of the tempered major third, major triad, and major seventh chord bring acoustic credibility to the CST organisation of the Ionian and Lydian chord scales. In each of the present tone combinations, the CT's have a greater presence than the T's, the AN of Ionian is absent, and the T's generally have a greater presence than the UT's.

In summary, the combined analytical application of present tone(s) (first quality of GSF) and their harmonic spectra (second quality) does bring greater clarity to the attributed GS than present tone(s) alone. The reduction of GS options is most striking in the example of the major third, reducing eight options to two. However, multiple options tend to remain, particularly when accounting for the relative presence of the partials. The analyses in Chapter 4 will further demonstrate that the second quality of GSF can be a valuable tool in reducing GS options, but one that rarely determines a singular GS.

3.10: Spectral Analysis: *g* values

Whilst spectral analysis can assist with attributing GS' to various PT combinations, it can play a greater role in determining *g* values within the GS'. This section will discern the *g* values within the four qualities of CST (CT/T/AN/UT) for all chord scales listed in Example 3.4a. The analysis will address each chord scale GS individually and – using the *g* value framework of CST – address the four qualities separately. The *g* values will be determined by observing the spectral content of the CT configurations that correspond to each chord scale GS. These configurations will consist of the single tone (C3), dyads from the root to other CT's (e.g., for a major seventh chord: C3+E3, C3+G3, and C3+B3), triads (e.g., C3+E3+G3), and seventh chords (e.g., C3+E3+G3+B3).

The *g* values will be based on equal-temperament. It was discussed in section '3.7: Spectral Analysis: Introduction and Data' how C3 and its spectra differ from the other tempered PT combinations and their spectra. Despite this distinction, the spectral content of C3 will be analysed alongside the other CT configurations to verify relationships with the natural harmonics. Nevertheless, the difference will be respected, and the greater number of tempered CT configurations means that they will dominate the analysis for each GS.

The *g* values will be distinguished by analysing the relative presence of the gravi-tones across the spectra of the CT configurations. With the Lydian Tensions (T's), for example, D (T9) is present in the spectra of all CT configurations and louder than F# (T#11) when all

CT's are present. This means that D is perceived to be closer than F#. The absence of A (T13) in all configurations means that it is perceived to be more distant than both D and F#. Lastly, whereas the analysis of the T's, AN's, and UT's will discuss all gravi-tones belonging to the appropriate CST quality, the CT analysis will omit the root because it is understood as *g*1.

It will become clear that the relative presence of gravi-tones is rarely uniform across all CT configurations in a GS. However, trends emerge between the configurations which are stored as *g* values in the long-term memory of the listener. Because the CT configurations analysed are basic to the listening experience of most cultures (certainly in the West), it seems likely that these *g* values describe the experience of most listeners.

However, it is not being argued that the *g* values are universal. Exceptions may occur where a culture or specific listener has had limited exposure to a given GS. Both versions of the whole-tone GS (+7 and 7b5 CT's), for example, are relatively rare compared to most other GS'. A more common challenge may arise from a listener's lack of exposure to the UT's. As section '3.5: Upper Tensions' illustrated, they can be found in the classical and jazz repertoires, but they are certainly not commonplace. It may even be that no listener has learned the *g* values of the UT's for all GS'.

The results of the analysis are shown in the form of tables and radar charts following each discussed GS. Like the incomplete Mixolydian GS shown in Example 3.4b, each radar chart shows the twelve gravi-tones positioned like numbers on a clockface. For each gravi-tone, the *g* value is shown by a dot positioned between the centre of the chart (*g*1) and the outer-line (*g*12).

Although twelve *g* values are theoretically possible for twelve gravi-tones, the results for each GS include at least one *g* value that is shared by two or more gravi-tones. In each case, these shared *g* values may represent either a 'true' measure of distance or demonstrate the limits of the spectral analysis. If the latter is true, then the methodology may be extended in future research for even finer *g* value distinctions.

To summarise, the spectral analysis has been of fundamental significance in understanding the distance problem of Gravitonicity. The analysis has proven that Arnold Schoenberg (1978 – originally published in 1911), Paul Hindemith (1941), and George Russell (1953/2001) were on the correct path in trying to derive distance from the harmonic series. With the benefit of *TS2* (IrcamLAB, 2021), this work has advanced to an appreciation of the spectra that belong to the actual tones played. It is hoped that the *g* values argued for and demonstrated here will assist practitioners, analysts, and educators from all musical backgrounds to better understand this intuitive property of harmony: distance.

***Ionian*:**

CT configurations analysed: C3, C3+E3, C3+G3, C3+B3, C3+E3+G3, C3+E3+G3+B3.

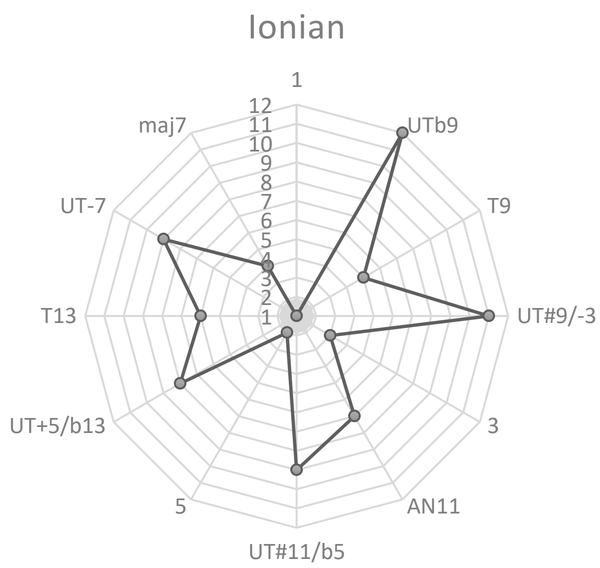
- **CT (1, 3, 5, maj7):** In the spectra of C3, G (5) occurs with a SP, MP, and WP. E (3) and B (maj7), on the other hand, only occur with WP, suggesting that G is closer. The spectra of C3+E3 confirm G being closer than B, with the former occurring twice as a SP and once as a MP, and the latter as a MP across three octaves. Similarly, the spectra of C3+B3 confirm G being closer than E, with the former occurring twice with SP and once with MP, and the latter only occurring with a weak MP. Therefore, G is *g*2.

  Lastly, the spectra of the major triad and the major seventh both point to E as *g*3 and B as *g*4, with E having a greater presence than B in the fourth and fifth octaves. This distance order correlates with those derived from the ‘basic space’ (Lerdahl, 2001, pp. 47) and the major key tonal hierarchy (Krumhansl and Kessler, 1982; Krumhansl, 2001) in Chapter 2.

- **T (T9, T13):** D (T9) occurs in the spectra of all CT configurations, notably with a SP for the major triad and major seventh chords. A (T13), on the other hand, only occurs with WP (and NP after 1000ms) in the spectra of C3, and with a WP in the spectra of C3+E3 and C3+B3. Therefore, T9 can be attributed with *g*5 and T13 with *g*6. This distinction builds upon the distance order expressed by the major key tonal hierarchy, which showed D and A with proximal ratings.
- **AN (AN11):** F (AN11) does not occur in the spectra of any CT configuration. This brings acoustic justification to CST and explains why the harmonic use of AN11 makes GSF its output (the Ionian GS). The latter leads to a friction that may be likened to dissonance or instability – as discussed in section '3.5: Upper Tensions'. Despite the complete absence of AN11 from the spectra of the CT configurations, it will be considered closer than the UT's because of its presence within the chord scale and its resultant melodic consonance – the same will be true for the AN's in other GS'. As the lone AN, AN11 can be attributed with *g*7.
- **UT (UTb9, UT#9/-3, UT#11/b5, UT+5/b13, UT-7):** The considerable presence of G#/Ab (UT+5/b13) in all CT configurations involving E3 shows that it is the closest of the UT's (*g*8). As the next closest after G#/Ab, it is difficult to split F#/Gb (UT#11/b5) and Bb (UT-7). Whilst Bb occurs with MP in all CT configurations, Gb is marginally louder than Bb in the spectra of the major triad and the major seventh. Whilst occupying the space of *g*9-*g*10, they will both be attributed with *g*9.
  D#/Eb (UT#9/-3) generally has minimal presence across the spectra of the CT configurations. Most notably, as the 5th natural harmonic of B, it occurs with a MP in the spectra of C3+B3 and the major seventh chord. D#/Eb has less presence than F#/Gb and Bb in both, granting UT#9/-3 *g*11. Db (UTb9) is the most distant (*g*12) because of its absence from the spectra of all CT configurations except for C3 and C3+E3, in which it occurs with NP and WP, respectively.

*g*1	*g*2	*g*3	*g*4	*g*5	*g*6	*g*7	*g*8	*g*9		*g*11	*g*12
1	5	3	maj7	T9	T13	AN11	UT+5/b13	UT#11/b5	UT-7	UT#9/-3	UTb9

Example 3.10a: Ionian *g* values (table).



Example 3.10a cont.: Ionian *g* values (radar chart).

***Dorian*:**

CT configurations analysed: C3, C3+Eb3, C3+G3, C3+Bb3, C3+Eb3+G3, C3+Eb3+G3+Bb3.

- **CT (1, -3, 5, -7):** As discussed in section '2.6: Tonal Hierarchies', the minor key tonal hierarchy (Krumhansl and Kessler, 1982; Krumhansl, 2001) and the Kafi tonal hierarchy (Castellano et. al, 1984; Krumhansl 2001) point to a distance order of (close to distant): 1, -3, 5, -7. This is clearly contested by the spectra of the CT configurations. G (5) has the strongest presence of all CT's (aside from the root) in the spectra of all CT configurations, suggesting that it is closer than Eb (-3) or Bb (-7). This reflects the rating of G in the Asavri (Phrygian) tonal hierarchy (Castellano et. al, 1984; Krumhansl 2001).

  In similar contrast to the tonal hierarchies, Bb has a stronger presence than Eb in the spectra of all CT configurations except for C3+Eb3. This exception is because Eb is sounded as a PT whereas Bb is not. The strong rating attributed to Eb in the hierarchies may be because of its minor-defining role. However, the spectra point to the distance order of 1 (*g*1), 5 (*g*2), -7 (*g*3), -3 (*g*4).
- **T (T9, T11, T13):** The minor key and Kafi tonal hierarchies referred to above both show proximal ratings for D (T9) and F (T11). This is confirmed by the spectra. D occurs with varying levels of presence in the spectra of all CT configurations, and F (T11) joins when Bb is a PT e.g., C3+Bb3 and C3+Eb3+G3+Bb3. Despite the omni-presence of D, F has a SP in the spectra of C3+Bb3 whereas D has a WP. In the spectra of the minor seventh chord, however, D is present in two octaves with a weak SP and MP, whereas F occurs in one octave as a weak SP. It can be concluded that T9 and T11 are equidistant.

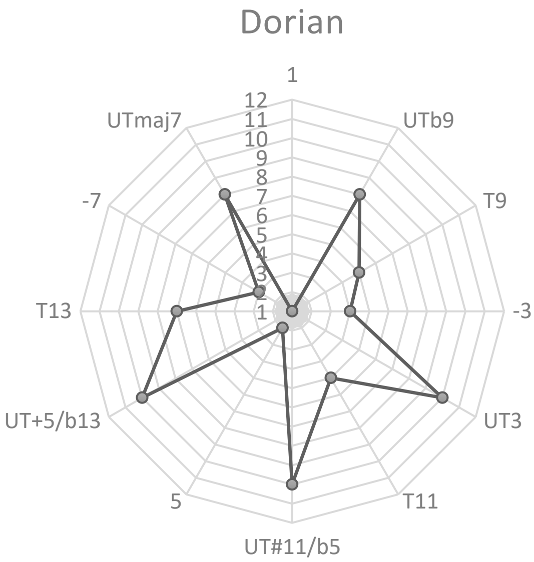
  The minor key and Kafi hierarchies also show A (T13) with a lower rating than D (T9) or F (T11). Again, this is confirmed by the spectra. A only occurs with WP (and NP after 1000ms) in the spectra of C3, and with a weak MP in the spectra of C3+Eb3. As a result, T9 and T11 may be judged to jointly occupy *g*5 and *g*6 (both represented as *g*5), whereas T13 may be attributed with *g*7. The greater distance of T13 reflects Nettles and Graf's T/AN indecision, as discussed in section '3.4: The Chord Scale Theory'.

- **UT (UTb9, UT3, UT#11/b5, UT+5/b13, UTmaj7):** The UT's with the greatest presence across the spectra of the CT configurations are Db (UTb9) and B (UTmaj7). Although B occurs alone in the spectra of C3+G3, both occur with close to identical MP in the spectra of C3+Eb3, the minor triad, and the minor seventh chord. This makes it difficult to distinguish between their relative distance, allowing them to share the space of *g*8-*g*9. They will be both be represented as *g*8.

  For *g*10-*g*12, E (UT3) only occurs with a WP in the spectra of C3, a relatively weak MP in the spectra of C3+Bb3, and NP in the spectra of the minor triad. F#/Gb (UT#11/b5) only occurs with a WP in the spectra of C3 and C3+Bb3, and with NP in the spectra of the minor triad. G#/Ab (UT+5/b13) only occurs with WP (and NP after 1000ms) in the non-tempered spectra of C3. The minimal presence of these UT's – particularly in the spectra of the minor triad and minor seventh chord – means that they share *g*10-*g*12. They will all be represented as *g*10.

*g*1	*g*2	*g*3	*g*4	*g*5		*g*7	*g*8		*g*10		
1	5	-7	-3	T9	T11	T13	UTb9	UTmaj7	UT3	UT#11/b5	UT+5/b13

Example 3.10b: Dorian *g* values (table).



Example 3.10b cont.: Dorian *g* values (radar chart).

***Phrygian*:**

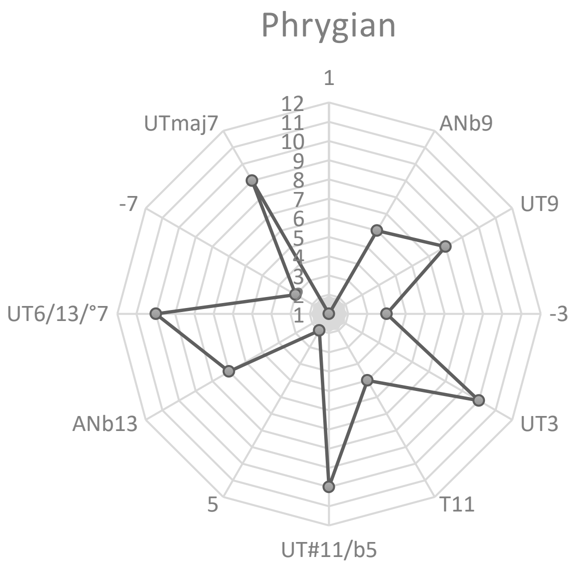
CT configurations analysed: C3, C3+Eb3, C3+G3, C3+Bb3, C3+Eb3+G3, C3+Eb3+G3+Bb3.

- **CT (1, -3, 5, -7):** The same as Dorian.
- **T (T11):** As the lone T, T11 can be attributed with *g*5.
- **AN (ANb9, ANb13):** The considerable presence of Db (ANb9) across the CT configurations and the contrastingly minimal presence of Ab (ANb13) are discussed in the UT section of Dorian. Their relative presence means that ANb9 and ANb13 can be attributed with *g*6 and *g*7, respectively, and suggests that ANb13 brings a greater challenge to GSF than ANb9.
- **UT (UT9, UT3, UT#11/b5, UT6/13/°7, UTmaj7):** It was discussed in the UT section of Dorian how E (UT3) and F#/Gb (UT#11/b5) are barely perceptible. For Phrygian, A

(UT6/13/°7) also belongs to this group. As the most distant gravi-tones, these occupy the values of *g*10-*g*12. They will all be represented as *g*10. For *g*8 and *g*9, the considerable presence of B (UTmaj7) was discussed in the UT section of Dorian. However, D (UT9) has notably greater presence than B in all CT configurations. Their relative presence makes UT9 *g*8 and UTmaj7 *g*9.

*g*1	*g*2	*g*3	*g*4	*g*5	*g*6	*g*7	*g*8	*g*9	*g*10		
1	5	-7	-3	T11	ANb9	ANb13	UT9	UTmaj7	UT3	UT#11/b5	UT6/13/°7

Example 3.10c: Phrygian *g* values (table).



Example 3.10c cont.: Phrygian *g* values (radar chart).

***Lydian*:**

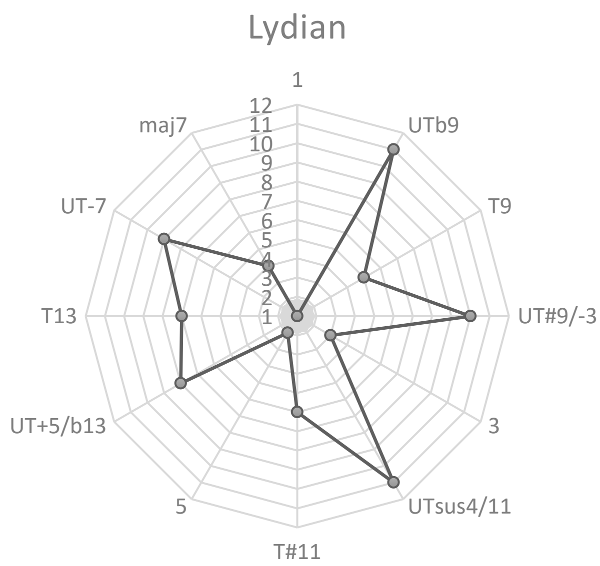
CT configurations analysed: C3, C3+E3, C3+G3, C3+B3, C3+E3+G3, C3+E3+G3+B3.

- **CT (1, 3, 5, maj7):** The same as Ionian.
- **T (T9, T#11, T13):** The considerable presence of D (T9) and the minimal presence of A (T13) was discussed in the T section of Ionian, with T9 being judged to be closer than T13. Although F# (T#11) has a stronger presence than D in the spectra of C3+B3 (10dB difference), D is omnipresent across the CT configurations and more present than F# in all other occurrences. This confirms T9 as *g*5.
  However, whereas A has only WP (and NP after 1000ms) in the spectra of C3, and WP in the spectra of C3+E3 and C3+B3, F# has a SP in the spectra of C3+B3, a MP in the spectra of the major seventh chord, a WP in the spectra of C3, and NP in the spectra of the major triad. It can be concluded that T#11 is *g*6 and T13 is *g*7. This distance order of T's correlates with the ratings of the Yaman tonal hierarchy (Castellano et. al, 1984; Krumhansl 2001) discussed in Chapter 2.
- **UT (UTb9, UT#9/-3, UTsus4/11, UT+5/b13, UT-7):** The spectra of the CT configurations clearly show G#/Ab (UT+5/b13) and Bb (UT-7) as the UT's with the strongest presence. However, whilst Bb is present in the spectra of all CT configurations, G#/Ab has greater presence when they both occur e.g., C3+E3, the major triad, and the major seventh chord. Therefore, UT+5/b13 and UT-7 can therefore be attributed with *g*8 and *g*9, respectively.
  D#/Eb (UT#9/-3) is the only other UT with notable presence. Occurring with a MP in the spectra of C3+B3 and with relatively weak MP in the spectra of the major seventh chord, UT#9/-3 can be attributed with *g*10. Db (UTb9) only occurs with a WP in the spectra of C3+E3 and NP in the spectra of C3 and the major triad. Whilst F (UTsus4/11) is completely absent, the barely perceptible presence of Db places them

at the same level. They occupy the space of *g*11-*g*12 and will both be represented as *g*11.

*g*1	*g*2	*g*3	*g*4	*g*5	*g*6	*g*7	*g*8	*g*9	*g*10	*g*11	
1	5	3	maj7	T9	T#11	T13	UT+5/b13	UT-7	UT#9/-3	UTb9	UTsus4/11

Example 3.10d: Lydian *g* values (table).



Example 3.10d cont.: Lydian *g* values (radar chart).

***Mixolydian*:**

CT configurations analysed: C3, C3+E3, C3+G3, C3+Bb3, C3+E3+G3, C3+E3+G3+Bb3.

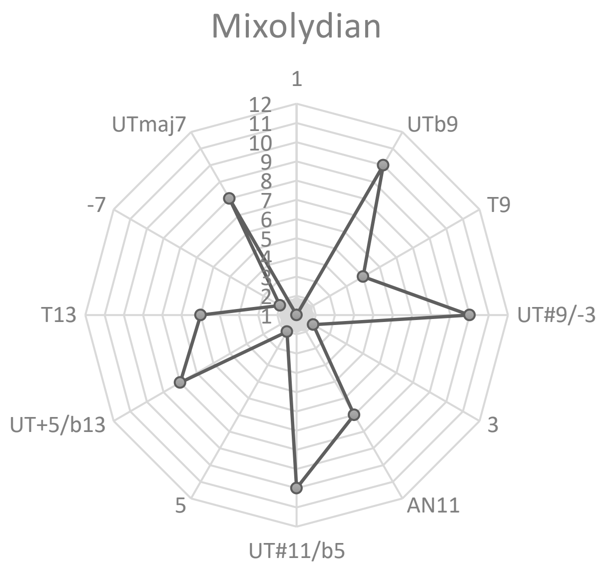
- **CT (1, 3, 5, -7):** It is more difficult to determine a distance order for dominant seventh CT's than for major or minor seventh chords. The spectra of C3 and the dyads suggest that G is closer than E (3) and Bb (-7). Moreover, in the same CT configurations, Bb has greater presence than E – the latter only occurring as relatively weak MP in the spectra of C3+Bb3 and as a WP in the spectra of C3. However, in the spectra of the major triad, the E and G partials in the fourth and fifth octaves have a similar presence – pointing to equidistant *g* values. More problematically, in the spectra of the dominant seventh chord, the E, G, and Bb partials in the fourth and fifth octaves have an almost identical presence. It might be concluded, therefore, that E, G, and Bb are equidistant. They all occupy the space of *g*2-*g*4 and will be represented as *g*2.
- **T (T9, T13):** A (T13) has only WP (and NP after 1000ms) in the spectra of C3, and WP in the spectra of C3+E3. By contrast, D (T9) has a considerable presence in the spectra of all CT configurations and is louder than A when both are present. Therefore, T9 is *g*5 and T13 is *g*6.
- **AN (AN11):** F (AN11) only occurs in the spectra of the dominant seventh chord as a fifth in the harmonic series of Bb, justifying it AN status. However, it occurs with a SP, suggesting that Mixolydian's AN11 offers less of a challenge to GSF than the same interval in Ionian. As the lone AN, AN11 can be attributed with *g*7.
- **UT (UTb9, UT#9/-3, UT#11/b5, UT+5/b13, UTmaj7):** G#/Ab (UT+5/b13) and B (UTmaj7) are the UT's with the strongest presence across the CT configurations. Of the two, only B is present in the spectra of C3 and C3+G3. However, in the spectra of C3+E3, G#/Ab has a SP whereas Bb sounds in three octaves with a MP. Both are strong MP's in the spectra of the major triad and the dominant seventh chord.

Because of their negligible difference in presence in the latter two CT configurations, UT+5/b13 and UTmaj7 can both be recognised as occupying the space of *g*8-*g*9. Both will be represented as *g*8.

Db (UTb9), D#Eb (UT#9/-3), and F#/Gb (UT#11/b5) are somewhat absent from the spectra of the CT configurations, only occurring with WP or NP. Db has arguably the strongest presence, occurring as a relatively strong WP in the spectra of the dominant seventh chord and C3+E3. However, this does not seem significant enough to distinguish it from D#/Eb and F#/Gb. Consequently, UTb9, UT#9/-3, and UT#11/b5 all occupy the space of *g*10-*g*12. They will all be represented as *g*10.

*g*1	*g*2			*g*5	*g*6	*g*7	*g*8		*g*10		
1	3	5	-7	T9	T13	AN11	UT+5/b13	UTmaj7	UTb9	UT#9/-3	UT#11/b5

Example 3.10e: Mixolydian *g* values (table).



Example 3.10e cont.: Mixolydian *g* values (radar chart).

***Mixolydian 7sus4*:**

CT configurations analysed: C3, C3+F3, C3+G3, C3+Bb3, C3+F3+G3, C3+F3+G3+Bb3.

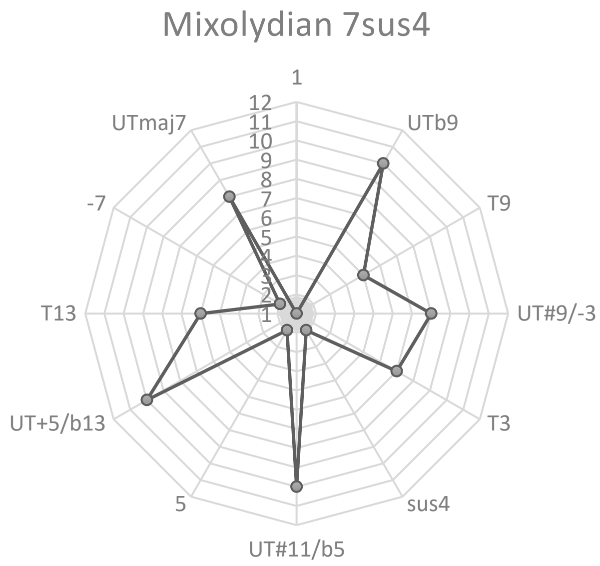
- **CT (1, sus4, 5, -7):** Determining the *g* values for the CT's of Mixolydian 7sus4 is similarly problematic to Mixolydian. Like Mixolydian, the spectra of C3 and the dyads seemingly offer solutions: G (5) has the greatest presence, followed by Bb (-7), then F (sus4). However, and again like Mixolydian, the spectra of the sus4 triad and the 7sus4 chord are problematic. F and G have nearly identical presence in the spectra of the triad, whereas F, G, and Bb have a similarly identical presence in the spectra of the 7sus4 chord. Consequently, it can be concluded that sus4, 5, and -7 share the space of *g*2-*g*4. All will be represented as *g*2.

- **T (T9, T3, T13):** Although A (T13) has a greater presence than D (T9) in the spectra of C3+F3, D (T9) is present in the spectra of all CT configurations and has a greater presence than A in the spectra of the sus4 triad and the 7sus4 chord. Therefore, T9 may be judged to be closer than T13. E (T3) has contrastingly minimal presence, only occurring with WP in the spectra of C3 and C3+F3 and with relatively weak MP in the spectra of C3+Bb3. As a result, T9, T13, and T13 may be respectively attributed with *g*5, *g*6, and *g*7. Like Dorian's T13, the greater distance of T3 resonates with Nettles and Graf's (1997) AN classification – as discussed in section '3.4: The Chord Scale Theory'.
- **UT (UTb9, UT#9/-3, UT#11/b5, UT+5/b13, UTmaj7):** D#/Eb (UT#9/-3) and B (UTmaj7) are generally the UT's with the strongest presence across the CT configurations. Although B occurs in the spectra of all CT configurations except for C3+Bb3, it has a similar presence to D#/Eb in the spectra of the sus4 triad and the 7sus4 chord. B has a greater presence than D#/Eb in the spectra of the 7sus4 chord, but the inverse is true for the sus4 triad. Because of this, it can be judged that UT#9/-3 and UTmaj7 jointly occupy the space of *g*8-*g*9. Both will be represented as *g*8.

  For *g*10-*g*12, Db (UTb9), F#/Gb (UT#11/b5), and G#/Ab (UT+5/b13) do not occur in the spectra of the 7sus4 chord and are present in the spectra of the sus4 triad only as weak NP's. Although F#/Gb occurs with a WP in the spectra of C3, C3+F3, and C3+Bb3, this does not seem significant enough to separate it from the largely absent Db and G#/Ab. Consequently, UTb9, UT#/11/b5, and UT+5/b13 can be judged to equally occupy *g*10-*g*12. All will be represented as *g*10.

*g*1	*g*2			*g*5	*g*6	*g*7	*g*8		*g*10		
1	sus4	5	-7	T9	T13	T3	UT#9/-3	UTmaj7	UTb9	UT#11/b5	UT+5/b13

Example 3.10f: Mixolydian 7sus4 *g* values (table).



Example 3.10f cont.: Mixolydian 7sus4 *g* values (radar chart).

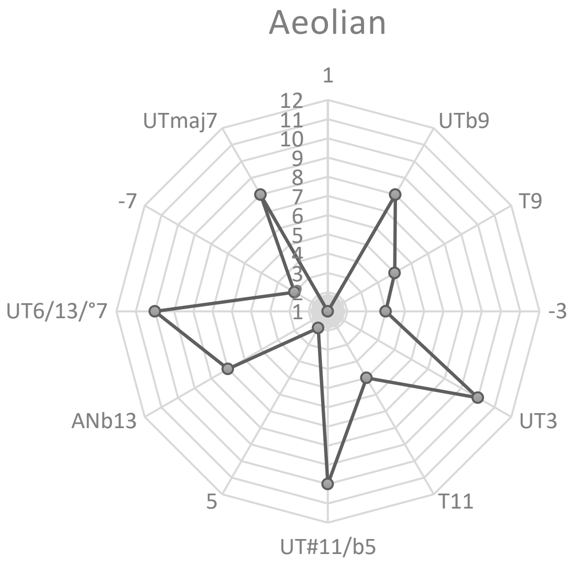
***Aeolian*:**

CT configurations analysed: C3, C3+Eb3, C3+G3, C3+Bb3, C3+Eb3+G3, C3+Eb3+G3+Bb3.

- **CT (1, -3, 5, -7):** The same as Dorian and Phrygian.
- **T (T9, T11):** The same as Dorian without T13.
- **AN (ANb13):** Ab (ANb13) was discussed for Phrygian. For Aeolian, the lone status of ANb13 means it can be attributed with *g*7.
- **UT (UTb9, UT3, UT#11/b5, UT6/13/°7, UTmaj7):** As discussed in the UT section of Dorian, the significant but indistinguishable presence of Db (UTb9) and B (UTmaj7) means that they share the space of *g*8-*g*9 – both represented as *g*8. For Dorian, it was explained that E (UT3), F#/Gb (UT#11/b5), and G#/Ab (UT+5/b13) jointly occupy *g*10-*g*12, and all are represented as *g*10. Aeolian's UT6/13/°7 has no greater presence than Dorian's UT+5/b13, only occurring with a weak MP in the spectra of C3+Eb3 and NP in the spectra of C3. For Aeolian, therefore, *g*10-*g*12 is occupied by UT3, UT#11/b5, and UT6/13/°7. All will be represented as *g*10.

*g*1	*g*2	*g*3	*g*4	*g*5		*g*7	*g*8		*g*10		
1	5	-7	-3	T9	T11	ANb13	UTb9	UTmaj7	UT3	UT#11/b5	UT6/13/°7

Example 3.10g: Aeolian *g* values (table).



Example 3.10g cont.: Aeolian *g* values (radar chart).

***Locrian*:**

CT configurations analysed: C3, C3+Eb3, C3+Gb3, C3+Bb3, C3+Eb3+Gb3, C3+Eb3+Gb3+Bb3.

- **CT (1, -3, b5, -7):** Gb (b5) and Bb (-7) have a similar presence across the CT configurations. Although Bb has greater presence in the spectra of C3 and the dyads, Gb is 10dB louder than Bb in the fourth octave of the diminished triad's spectra. Additionally, Gb and Bb have equivalent presence in the fourth and fifth octaves of the -7b5 chord's spectra. As a result, b5 and -7 may be regarded as equidistant. Eb (-3) has less presence than Gb and Bb across all CT configurations. It occurs with NP in the spectra of C3, WP in the spectra of C3+Eb3, and with notably less presence than Gb and Bb in the fourth and fifth octaves of the diminished triad's and

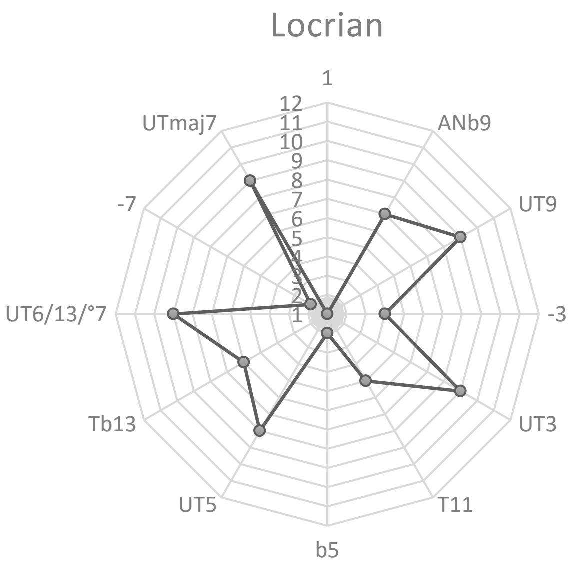
-7b5 chord’s spectra. Therefore, b5 and -7 can be judged to jointly occupy *g*2-*g*3 (both will be represented as *g*2) whereas -3 occupies *g*4.

- **T (T11, Tb13):** Ab (Tb13) is absent from the spectra of most CT configurations, only occurring with WP (and NP after 1000ms) in the spectra of C3. By contrast, F (T11) has a SP in the spectra of C3+Gb3, C3+Bb3, and the -7b5) chord, and a MP in the spectra of C3+Eb3. It can be judged that T11 is *g*5 and Tb13 is *g*6.
- **AN (ANb9):** As the lone AN, ANb9 is *g*7. However, as the fifth in the harmonic series of Gb (b5), Locrian’s ANb9 (Db) has a stronger presence than in Phrygian. Occurring with SP in the spectra of the diminished triad and the -7b5 chord, MP in in the spectra of C3+Eb3, and NP in the spectra of C3, Db has greater presence than Tb13 and even brings a challenge to T11. Whilst this does not change its AN status, it suggests that ANb9 causes a smaller challenge to GSF than the AN’s in other GS’.
- **UT (UT9, UT3, UT5, UT6/13/°7, UTmaj7):** G (UT5) has easily the strongest presence of all UT’s in every CT configuration, making it *g*8. Beyond this, it is difficult to determine the *g* values of the remaining UT’s even though they are all present in some capacity across the CT configurations. No UT’s occur with noteworthy presence in the spectra of the diminished triad, and only D (UT9) occurs with weak MP in -7b5 chord’s spectra.

  Likewise, the spectra of C3 and the dyads do not bring any convincing evidence for the *g* values. For example, D’s weak MP presence in the spectra of the -7b5 chord and a strong MP in the spectra C3+Bb3 suggest that it is the closest of the remaining UT’s. However, D is absent from the spectra of C3+Gb3 whereas E (UT3) and B (UTmaj7) both have MP. The spectra of C3 also show D with a proximal presence to A (UT6/13/°7) and B. As a result, *g*9-*g*12 are jointly occupied by UT9, UT3, UT6/13/°7, and UTmaj7. All will be represented as *g*9.

*g*1	*g*2		*g*4	*g*5	*g*6	*g*7	*g*8	*g*9			
1	b5	-7	-3	T11	Tb13	ANb9	UT5	UT9	UT3	UT6/13/°7	UTmaj7

Example 3.10h: Locrian *g* values (table).



Example 3.10h cont.: Locrian *g* values (radar chart).

***Lydian b7*:**

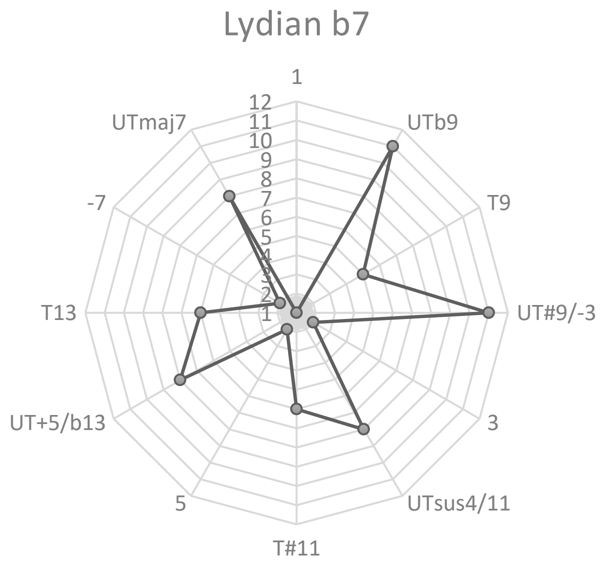
CT configurations analysed: C3, C3+E3, C3+G3, C3+Bb3, C3+E3+G3, C3+E3+G3+Bb3.

- **CT (1, 3, 5, -7):** The same as Mixolydian.
- **T (T9, T#11, T13):** As discussed in the T section of Mixolydian, D (T9) has a considerable presence in all CT configurations whereas A (T13) is barely present. F# (T#11) has a similar presence to A, only occurring with WP in the spectra of C3 and NP in the spectra of the triad. This lack of presence means T#11 and T13 jointly occupy *g*6-*g*7 (both represented as *g*6), whereas T9 is *g*5.
- **UT (UTb9, UT#9/-3, UTsus4/11, UT+5/b13, UTmaj7):** The presences of F (UTsus4/11), G#/Ab (UT+5/b13), and B (UTmaj7) are competitive across the CT configurations. B is the most present in the spectra of C3, C3+G3, and the major triad. G#/Ab, on the other hand, is the most present in the spectra of C3+E3 and G#/Ab5 is only 2dB quieter than B4 in the spectra of the major triad and the dominant seventh chord. F is the only UT present in the spectra of C3+Bb3 and is the loudest in the dominant seventh chord's spectra. The individual merits of UTsus4/11, UT+5/b13, and UTmaj7 means that they jointly occupy *g*8-*g*10 and will all be represented as *g*8.

  Lastly, Db (UTb9) and D#/Eb (UT#9/-3) do not occur with notable presence in the spectra of any CT configuration – the strongest occurrence is Db in the spectra of the dominant seventh chord with a WP. Because of this, they can be judged to jointly occupy *g*11-*g*12 and will both be represented as *g*11.

g1	g2			g5	g6		g8			g11	
1	3	5	-7	T9	T#11	T13	UTsus4/11	UT+5/b13	UTmaj7	UTb9	UT#9/-3

Example 3.10i: Lydian b7 *g* values (table).



Example 3.10i cont.: Lydian b7 *g* values (radar chart).

***altered*:**

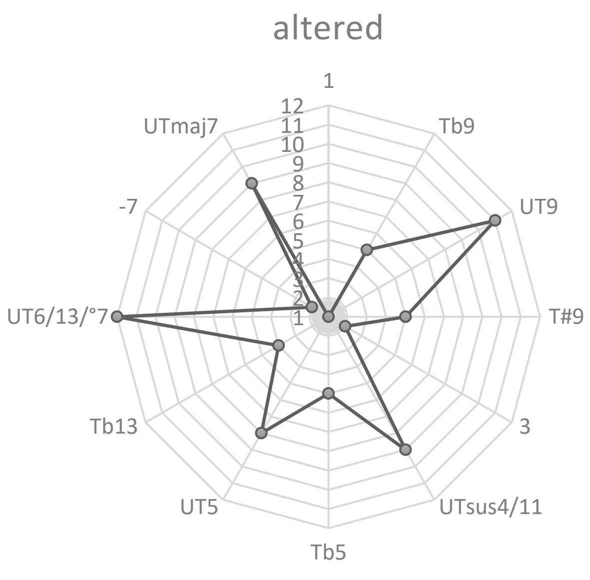
CT configurations analysed: C3, C3+E3, C3+Bb3, C3+E3+Bb3.

- **CT (1, 3, -7):** The *g* values of the altered CT's are the same as Mixolydian and Lydian b7 without 5. Whilst the spectra of the 7no5 chord (C3+E3+Bb3) suggest that E (3) is closer than Bb (-7), this is challenged by the greater presence of Bb than E in the spectra of C3. Moreover, the levels of Bb in the spectra of C3+E3 and E in the spectra of C3+Bb3 are proximal. It can be concluded that 3 and -7 jointly occupy *g*2-*g*3 and both will be represented as *g*2.
- **T (Tb9, T#9, Tb5, Tb13):** Ab (Tb13) is significantly louder than the other T's in the spectra of C3+E3 and has a MP as the lone T in the 7no5 chord's spectra. Tb13 can therefore be recognised as *g*4. However, it is harder to distinguish the relative distance of Db (Tb9), Eb (T#9), and Gb (Tb5). Of the three, Gb has the greatest presence, occurring with WP in the spectra of C3 and C3+Bb3. However, Gb is absent from the spectra of C3+E3 whereas Db and Eb both have WP's. The absence of all three from the spectra of the 7no5 chord does not help. Consequently, Tb9, T#9, and Tb5 can be recognised as jointly occupying *g*5-*g*7. All will be represented as *g*5. Additionally, Tb5's status as one of the more distant T's brings further justification for why it is not a CT – as discussed in section '3.4: The Chord Scale Theory'.
- **UT (UT9, UTsus4/11, UT5, UT6/13/°7, UTmaj7):** G (UT5) is distinctly the most present of the UT's, sounding with a SP in all CT configurations. In contrast, A (UT6/13/°7) is the least present of the UT's across the CT configurations, occurring with WP (and NP after 1000ms) in the spectra of C3 and a weak MP in the spectra of C3+E3. Therefore, UT5 is *g*8 and UT6/13/°7 is *g*12.

  It is more difficult to distinguish the *g* values of D (UT9), F (UTsus4/11), and B (UTmaj7). Whilst D has a stronger presence than Bb in the spectra of C3, B is stronger than D in the spectra of C3+E3 and F is stronger than D in the spectra of C3+Bb3. Additionally, the spectra of the 7no5 chord include B and D with SP whereas D has a MP. These observations suggest that UT9 is the most distant (*g*11), whereas UTsus4/11 and UTmaj7 jointly occupy *g*9-*g*10 – both will be represented as *g*9.

*g*1	*g*2		*g*4	*g*5			*g*8	*g*9		*g*11	*g*12
1	3	-7	Tb13	Tb9	T#9	Tb5	UT5	UTsus4/11	UTmaj7	UT9	UT6/13/°7

Example 3.10j: altered *g* values (table).



Example 3.10j cont.: altered *g* values (radar chart).

***melodic minor*:**

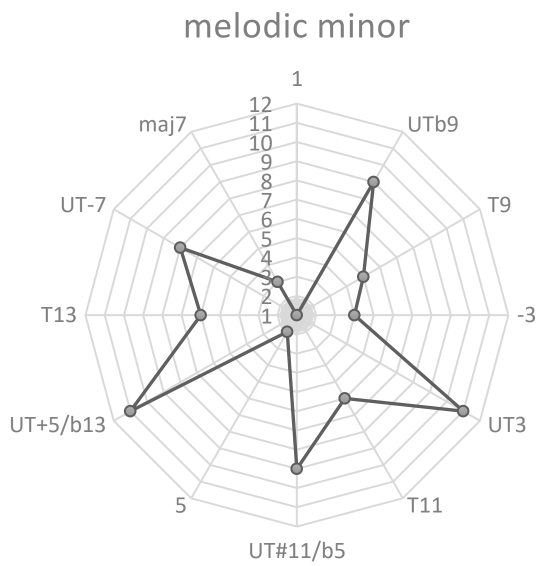
CT configurations analysed: C3, C3+Eb3, C3+G3, C3+B3, C3+Eb3+G3, C3+Eb3+G3+B3.

- **CT (1, -3, 5, maj7):** G (5) has the strongest presence in the spectra of all CT configurations except for C3+B3 where it is competitively matched with B (maj7). Whilst Eb has a stronger presence than B in the spectra of the minor triad, the inverse is true in the spectra of C3, C3+G3, C3+B3, and, perhaps most importantly, the -maj7 chord. Therefore, 5 is *g*2, maj7 is *g*3, and -3 is *g*4.
- **T (T9, T11, T13):** D (T9) has the strongest presence of the T's in the spectra of all CT configurations, meaning that it is *g*5. By contrast, A (T13) occurs with WP (and NP after 1000ms) in the spectra of C3, WP in the spectra of C3+Bb3, and occurs at a proximal level to F (T11) in the spectra of C3+Eb3. The general absence of T11 and T13 means that they can be recognised as jointly occupying *g*6-*g*7. Both will be represented as *g*6.
- **UT (UTb9, UT3, UT#11/b5, UT+5/b13, UT-7):** Bb (UT-7) has the strongest presence of the UT's in all CT configurations. For the spectra of C3+B3, it might be argued that F#/Gb (UT#11/b5) is louder than Bb. However, whilst F#/Gb5 is individually louder than any of the Bb partials, it can be argued that the collective presence of Bb across three octaves is stronger. Consequently, UT-7 is *g*8.

  The weak SP of F#/Gb in the spectra of C3+B3 is reflected by a strong MP in that of the -maj7 chord. In comparison, Db (UTb9) has a marginally weaker MP presence in the spectra of the -maj7 chord, and MP in the spectra of C3+Eb3 and the minor triad. The individual merits of UT#11/b5 and UTb9 means that they can be judged to jointly occupy *g*9-*g*10. Both will be represented as *g*9. Lastly, E (UT3) only occurs with a weak MP in the spectra of C3+B3 and G#/Ab (UT+5/b13) only occurs with a WP (and NP after 1000ms) in the spectra of C3. They can be judged to share *g*11-*g*12. Both will be represented as *g*11.

*g*1	*g*2	*g*3	*g*4	*g*5	*g*6		*g*8	*g*9		*g*11	
1	5	maj7	-3	T9	T11	T13	UT-7	UTb9	UT#11/b5	UT3	UT+5/b13

Example 3.10k: melodic minor *g* values (table).



Example 3.10k cont.: melodic minor *g* values (radar chart).

***whole-tone +7*:**

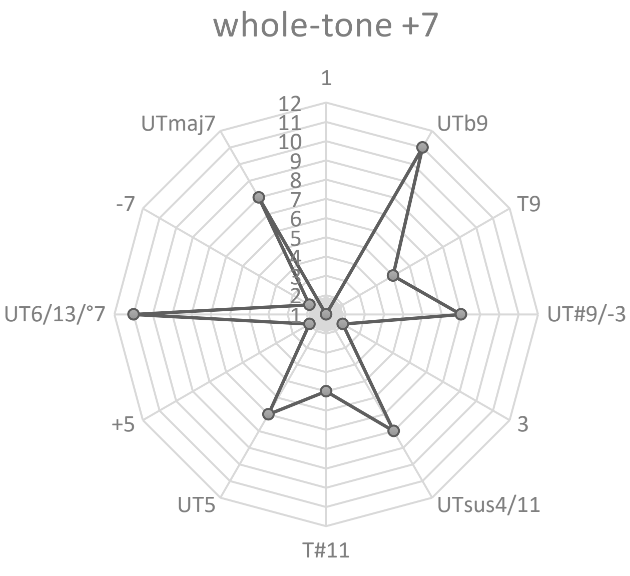
CT configurations analysed: C3, C3+E3, C3+G#3, C3+Bb3, C3+E3+G#3, C3+E3+G#3+Bb3.

- **CT (1, 3, +5, -7):** The *g* values of the whole-tone +7 CT's are difficult to distinguish from the spectra of the CT configurations. This is epitomised by the spectra of the +7 chord, in which the presence of E (3), G# (+5), and Bb (-7) are proximal. Whilst Bb has the slightly weakest presence, this may be because the Bb3 PT is marginally quieter than the E3 and G#3 PT's. The spectra of the triad display similarly proximal levels for E and G#, as does the spectra of C3 for E and Bb. Consequently, 3, +5, and -7 can be judged to jointly occupy *g*2-*g*4. They will all be represented as *g*2.
- **T (T9, T#11):** Distinguishing the *g* values of the T's is no easier than the CT's. Neither D (T9) or F# (T#11) are present in the spectra of the +7 chord. Moreover, whilst D occurs with a MP in the spectra of C3+E3 and with greater presence than F# in the spectra of C3, F# occurs alone with a WP in the spectra of C3+G#3 and C3+Bb3. In summary, T9 and T#11 jointly occupy *g*5-*g*6 and both will be represented as *g*5.
- **UT (UTb9, UT#9/-3, UTsus4/11, UT5, UT6/13/°7, UTmaj7):** Akin to Locrian and altered, G (UT5) has the strongest presence of the UT's in all CT configurations and therefore assumes *g*7. In contrast, Db (UTb9) and A (UT6/13/°7) have the weakest presence across the CT configurations. Db only occurs with WP in the spectra of C3+E3 and with NP in the spectra of C3 and the augmented triad. A, on the other hand, has a singular weak SP in the spectra of C3+G#3 and WP (and NP after 1000ms) in the spectra of C3. Therefore, UTb9 and UT6/13/°7 jointly occupy *g*11-*g*12 and both will be represented as *g*11.

  The UT's representing the remaining *g* values (*g*8-*g*10) are more difficult to distinguish. In the spectra of the +7 chord, the presences of D#/Eb (UT#9/-3), F (UTsus4/11), and B (UTmaj7) are proximal. The same is true for B and Eb in the spectra of C3 and the augmented triad. Whilst Eb is the only one of three to occur in the spectra of C3+G#3, and likewise for F in the spectra of C3+Bb3, these threads do not bring enough evidence to distinguish the *g* values of the remaining UT's. As a result, UT#9/-3, UTsus4/11, and UTmaj7 jointly occupy *g*8-*g*10 and will all be represented as *g*8.

*g*1	*g*2			*g*5		*g*7	*g*8			*g*11	
1	3	+5	-7	T9	T#11	UT5	UT#9/-3	UTsus4/11	UTmaj7	UTb9	UT6/13/°7

Example 3.10l: whole-tone +7 *g* values (table).



Example 3.10l cont.: whole-tone +7 *g* values (radar chart).

***whole-tone 7b5*:**

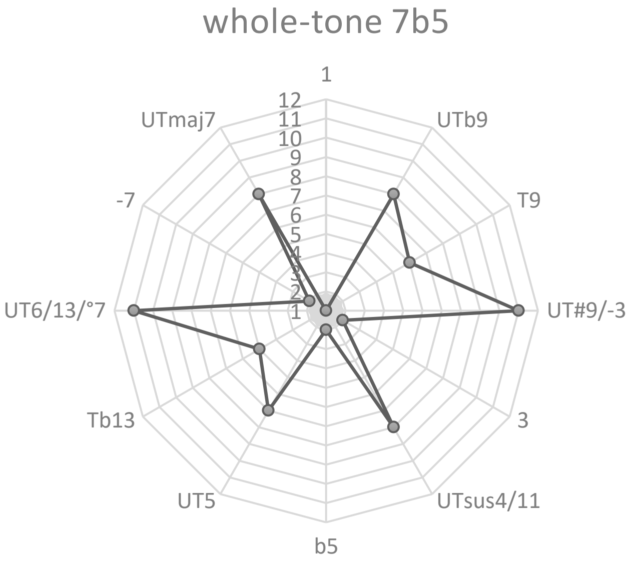
CT configurations analysed: C3, C3+E3, C3+Gb3, C3+Bb3, C3+E3+Gb3, C3+E3+Gb3+Bb3.

- **CT (1, 3, b5, -7):** The *g* values of the whole-tone 7b5 CT's are no easier to distinguish than those of the +7 version. E (3) and Gb (b5) have an almost identical presence in the spectra of C3+E3+Gb3 and the 7b5 chord. By comparison, Bb (-7) has notably less presence in the triad's spectra and only marginally less in the 7b5 chord's spectra. The former may be accredited to its absence from the PT's, and the latter to its slightly lower level as a PT. Although E has a marginally stronger presence than Gb in the spectra of C3 and C3+Bb3, and Bb has generally strong presence in the spectra of C3 and the dyads, the triad and the 7b5 chord may be recognised as the main CT configurations. Consequently, 3, b5, and -7 can judged to jointly occupy *g*2-*g*4. All will be represented as *g*2.
- **T (T9, Tb13):** Ab (Tb13) occurs with a SP in the spectra of C3+E3 and the 7b5 chord, a strong MP in the triad's spectra, a strong WP in the spectra of C3+E3, and a WP (and NP after 1000ms) in the spectra of C3. Whilst D (T9) occurs with a strong WP and NP in the spectra of C3, and with relatively strong WP in the spectra of C3+E3 and C3+Bb3, it does not occur in the triad's spectra and has a weaker presence than Ab in the spectra of the 7b5 chord. As a result, Tb13 and T9 can be judged to represent *g*5 and *g*6, respectively.
- **UT (UTb9, UT#9/-3, UTsus4/11, UT5, UT6/13/°7, UTmaj7):** Like other GS' that contain it, G (UT5) occurs as the strongest of the UT's in the spectra of all CT configurations. Therefore, UT5 represents *g*7. The presences of Db (UTb9), F (UTsus4/11), and B (UTmaj7) are largely equivalent across the spectra of the CT configurations. B and Db have the same SP in the spectra of the 7b5 chord and share a similar presence in the spectra of C3+Gb3 and the triad.

F is only 2dB louder than Db and B in the spectra of the 7b5 chord, notably louder than both in the spectra of C3+Gb3, and independent of both in C3+Bb3's spectra. However, F is absent from the triad's spectra whilst Db and B have SP's. The various merits of UTb9, UTsus4/11, and UTmaj7 across the spectra of the CT configurations suggests that they jointly occupy *g*8-*g*10. All will be represented as *g*8. Lastly, D#/Eb (UT#9/-3) and A (UT6/13/°7) are both absent from the spectra of all CT configurations except for C3 and C3+E3. Both occur with NP in the former and WP in the latter. Their general absence and proximal presence when they do occur suggests that they jointly occupy *g*11-*g*12 – both will be represented as *g*11.

*g*1	*g*2			*g*5	*g*6	*g*7	*g*8			*g*11	
1	3	b5	-7	Tb13	T9	UT5	UTb9	UTsus4/11	UTmaj7	UT#9/-3	UT6/13/°7

Example 3.10m: whole-tone 7b5 *g* values (table).



Example 3.10m cont.: whole-tone 7b5 *g* values (radar chart).

***symmetric dominant*:**

CT configurations analysed: C3, C3+E3, C3+G3, C3+Bb3, C3+E3+G3, C3+E3+G3+Bb3.

- **CT (1, 3, 5, -7):** The same as Mixolydian and Lydian b7.
- **T (Tb9, T#9, T#11, T13):** All T's in the spectra of the CT configurations have either WP or NP, casting doubt on their role for determining *g* values. Moreover, even if these partials are acknowledged, they exhibit few consistencies that can be used as evidence. For example, whilst Db (Tb9) has a strong WP in the spectra of the dominant seventh chord, it only has a similar presence in the spectra of C3+E3. Likewise, although F# (T#11) has a strong WP in the spectra of C3+Bb3, it only has a similar presence in the spectra of C3. D# (T#9) and A (T13) have similarly

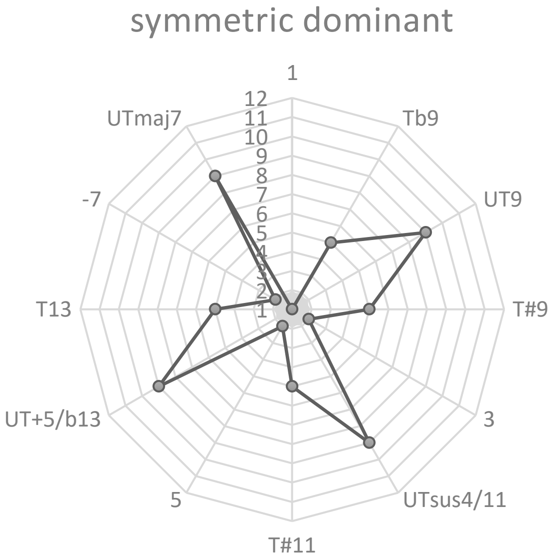
inconsistent presence across the CT configurations. In summary, all four T's can only be judged to occupy *g*5-*g*8 and all will be represented as *g*5.

- **UT (UT9, UTsus4/11, UT+5/b13, UTmaj7):** The UT's of symmetric dominant are no easier to distinguish *g* values for than the T's. In the spectra of the dominant seventh chord, D (UT9) and F (UTsus4/11) have a greater presence than G#/Ab (UT+5/b13) and B (UTmaj7), although all are proximal. Dissimilarly, the spectra of the major triad show B and D with a stronger presence than G#/Ab.

  Again, contrastingly, G#/Ab has a stronger presence than B or D in the spectra of C3+E3. F has a stronger presence than D in the spectra of C3+Bb3, and, as for the spectra of C3+G3, D is louder than B in the fifth octave and B is louder than D in the sixth octave. These mixed messages indicate that all the UT's occupy *g*9-*g*12. All will be represented as *g*9.

*g*1	*g*2			*g*5				*g*9			
1	3	5	-7	Tb9	T#9	T#11	T13	UT9	UTsus4/11	UT+5/b13	UTmaj7

Example 3.10n: symmetric dominant *g* values (table).



Example 3.10n cont.: symmetric dominant *g* values (radar chart).

***symmetric diminished*:**

CT configurations analysed: C3, C3+Eb3, C3+Gb3, C3+A3, C3+Eb3+Gb3, C3+Eb3+Gb3+A3.

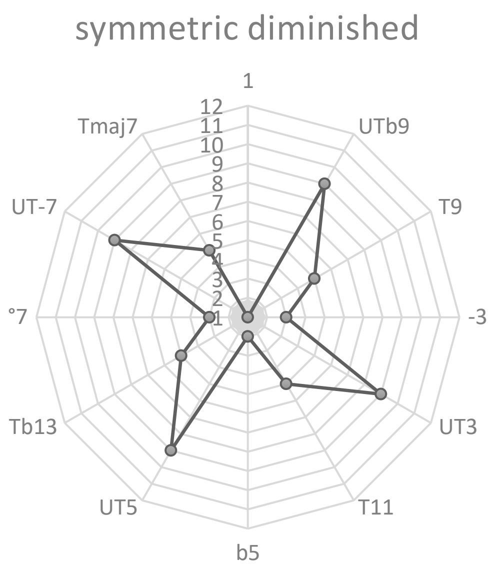
- **CT (1, -3, b5, °7):** The spectra of the diminished seventh chord features Gb (b5) with a greater presence than Eb (-3) or A (°7). Similarly, Gb has a stronger presence than Eb in the spectra of the diminished triad. This indicates that b5 is *g*2. In the spectra of the diminished seventh chord, A occurs with greater presence in the fourth and fifth octaves than Eb. However, because A only occurs otherwise with a weak MP in the spectra of C3+Eb3, and a WP (and NP after 1000ms) in the spectra of C3, it is difficult to distinguish the *g* values of A and Eb. Consequently, -3 and °7 can be judged to jointly represent *g*3-*g*4 and both will be represented as *g*3.

- **T (T9, T11, Tb13, Tmaj7):** There are no T's in the spectra of the diminished triad and only D (T9) occurs with a weak MP in the spectra of the diminished seventh chord. Whilst D's lone presence is mirrored in the spectra of C3+A3 and it is stronger than B (Tmaj7) in the spectra of C3, the general weakness of its presence casts uncertainty on its potential as the closest T.
  Moreover, this potential is challenged by the proximal presence of B in the spectra of C3, and the proximal presence of F (T11) and B in the spectra of C3+Eb3. The latter also diminished F's potential at the closest T, as promised by its SP in the spectra of C3+Gb3.
  To summarise, the lack of consistently strong presences across the CT configurations prevents the T's from securing individual *g* values. Therefore, although Ab (Tb13) only has a WP (and NP after 1000ms) in the spectra of C3, there is no reason to distinguish it from the other T's. All T's occupy *g*5-*g*8 and will all be represented as *g*5.
- **UT (UTb9, UT3, UT5, UT-7):** It is no easier to distinguish the *g* values of the UT's in symmetric diminished. Despite the unusual presence of all UT's in all CT configurations, this does not assist with determining their *g* values. The difficulty is epitomised by the spectra of the diminished seventh chord, in which the presences of Db (UTb9), E (UT3), G (UT5), and Bb (-7) are all proximal. Moreover, whilst G4 and E5 are the strongest partials, Bb and Db are both present in two octaves – although Db is marginally quieter than Bb.
  The spectra of C3+Eb3, C3+Gb3, and the diminished triad seemingly point to G and Bb being closer than E and Db. However, this is challenged by the spectra of: C3, in which Bb and E are proximal; C3+A3, in which E and Db have SP and Bb has MP; and the aforementioned diminished seventh chord, in which the presences of the

UT's are somewhat equivalent. Consequently, the UT's can only be judged to jointly occupy *g*9-*g*12 and will be represented as *g*9.

*g*1	*g*2	*g*3		*g*5				*g*9			
1	b5	-3	°7	T9	T11	Tb13	Tmaj7	UTb9	UT3	UT5	UT-7

Example 3.10o: symmetric diminished *g* values (table).

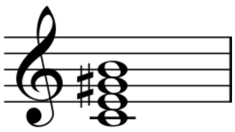


Example 3.10n: symmetric dominant *g* values (radar chart).

<u>3.11: Chromatically Altered Chord Scale GS'</u>

In addition to the chord scales of Example 3.4a – which have become the GS' of section '3.10: Spectral Analysis: *g* values' – others exist which are approached by the Nettles & Graf (1997) text but dealt with less systematically. These include: 'Mixolydian with alterations' (up to three available alterations from b9/#9/b5/b13- four would create an altered chord scale) which can be more clearly shown with the appropriate alterations written out e.g., Mixolydian (#9), Mixolydian (b9, #9, b13) etc; Lydian b7 (#9); Dorian (b9); and Locrian (♮9).

These can be considered as 'chromatically altered chord scale GS'', in which one or more of the scale degrees are raised or lowered by a semi-tone. Considering the number of chord scales in Example 3.4a and their component intervals, these alterations result in a seemingly infinite number of chord scales and, subsequently, GS'. The *g* values for chromatically altered GS' will be calculated as and when required during the analysis of Chapter 4. To demonstrate this approach, Example 3.11a shows a C+maj7 chord.



Example 3.11a: C+maj7 chord.

C+maj7 does not correspond to any of the GS' in section '3.10: Spectral Analysis: *g* values'. Scale degrees 3 and maj7 suggest that either Ionian or Lydian would be appropriate. However, the +5 scale degree indicates that one of these GS' has been chromatically altered. To determine whether the appropriate GS is based on Ionian or Lydian, the data tables of Example 3.7c can be consulted.

The +maj7 chord PT combination (C3+E3+G#3+B3) is not included in the tables as the data is specific to the chord scales of Example 3.4a. In the second table of Example 3.7c, the spectral content of the augmented triad (C3+E3+G#3) does not include the Ionian-confirming F (AN11), and the Lydian-confirming F# (T#11) only occurs in the outer reaches of the NP's. Nevertheless, the spectra of the major seventh interval (C3+B3 in the first table of Example 3.7c) includes the Lydian-confirming F# (T#11) with a SP.

This suggests that Lydian – with the chromatic alteration of a sharpened fifth – is the theoretically-appropriate GS for the C+maj7 chord in Example 3.11a. Example 3.11b shows a Lydian (#5) chord scale, also popularly known as a 'Lydian Augmented' or the third mode of the melodic minor scale. Despite being a unique GS, the chord scale retains the 'Lydian' nomenclature for two reasons. Firstly, it is more convenient to make the alterations to a familiar mode than to invent a new name. Secondly, it may be that GSF understands and attributes the chromatically altered GS' through a cognitive link with their unaltered forms.

Example 3.11b: Lydian (#5) chord scale.

The +5 scale degree replaces 5 (which has now become UT5) as a CT, changing the corresponding seventh chord from maj7 (1 3 5 7) to +maj7 (1 3 +5 7). Whilst T9 and T#11 remains unchanged, Lydian's T13 becomes AN13 because the altered fifth now sits a semi-tone below. Such changes to the AN's in chord scale GS' are common amongst the chromatically altered versions.

To derive the *g* values of this GS, the same method can be used as in section 3.10. As noted above, the +maj7 CT configuration is not included in the tables of Example 3.7c. However, all others are included and can be used to reach meaningful conclusions for the *g* values. As in section 3.10, the analysis below handles the CT/T/AN/UT qualities individually before representing the *g* values in table form and as a radar chart.

***Lydian (#5)*:**

CT configurations analysed: C3, C3+E3, C3+G#3, C3+B3, C3+E3+G#3.

- **CT (1, 3, +5, maj7):** Like the similar CT's of whole-tone +7 (1 3 +5 -7), it is difficult to distinguish the *g* values of the Lydian (#5) CT's. In the spectra of C3, E's (3) strong WP in the fifth and sixth octaves suggests that it closer than the single octave WP of G# (+5) and B (maj7). E's victory over G# is supported by the latter's absence in the spectra of C3+B3.
  The spectra of the augmented triad also appear to support this hypothesis with E having a greater presence than G# across three octaves. However, because the disparity in presence gets smaller across the three octaves, it can be accredited to E being louder than G# in the present tones e.g., E3 = -31dB, G# = -34dB. From the individual merits of E and G#, it may be concluded that their *g* values are level.
  B (maj7) appears to be equidistant with E from their joint absence from the spectra of C3+G#3. Problematically, the spectra of C3+E3 seemingly demonstrate that G# is

closer than B: G# occurs as a SP and maximally strong WP whereas B occurs in three octaves as a MP. B's absence from the PT's of the augmented triad sheds no further light on this problem. Consequently, E (3), G# (+5), and B (maj7) can be judged to jointly occupy *g*2-*g*4. All will be represented as *g*2.

- **T (T9, T#11):** In contrast to the Lydian GS, F# (T#11) has a greater presence in the CT configurations than D (T9). Whilst D has a stronger presence than F# in the spectra of C3 and C3+E3, the inverse is true in the spectra of C3+G#3, C3+B3, and the augmented triad (although F# only occurs as a weak NP). The minimal presence of D compared to the Lydian GS is because G, of which D is the 3rd harmonic, is not part of the CT configurations. It can also be theorised that, as the 3rd harmonic of B, F# would also have a stronger presence than D in the spectra of the +maj7 chord. Consequently, T#11 is *g*5 and T9 is *g*6.
- **AN (AN13):** A (AN13) has a relatively weak SP in the spectra of C3+G#3 and a WP in the spectra of C3 (NP after 1000ms), C3+E3, and C3+B3. It is absent from the spectra of the augmented triad and – judging from A's absence from most seventh chords' spectra – can be theorised not to present in the spectra of the +maj7 chord either. It is more present than some of the AN's from other GS' (e.g., AN11 in Ionian) but not as present as others (e.g., ANb9 in Locrian). Therefore, Lydian (#5)'s AN13 can be judged to cause a medium challenge to GSF. As the lone AN, AN13 can be attributed with *g*7.
- **UT (UTb9, UT#9/-3, UTsus4/11, UT5, UT-7):** Like other GS' containing UT5, G (UT5) occurs with the strongest presence of the UT's in every CT configuration – making it *g*8. The next strongest UT's, Bb (UT-7) and D#/Eb (UT#9/-3), have a similar presence across the CT configurations. Bb has the stronger presence of the two in the spectra of: C3, in which Bb occurs with MP and WP and D#/Eb occurs with

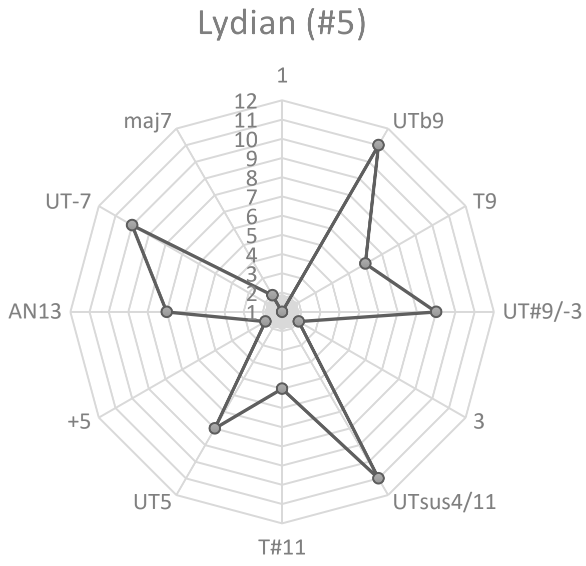
NP; C3+E3, in which Bb has MP and D#/Eb has WP; and C3+B3, in which Bb occurs twice with MP and once with WP, whereas D#/Eb occurs once with MP.

In contrast, D#/Eb has the stronger presence of the two in the spectra of: C3+G#3, in which D#/Eb has a SP and Bb has a WP; and the augmented triad, in which D#/Eb has a SP and Bb is absent. D#/Eb's presence spike in these CT configurations arises because of its status as the 3^{rd} harmonic of G# (+5). Therefore, whilst the spectral content of the +maj7 chord is not included in Example 3.7c, it can be theorised that it would contain D#/Eb with a SP. Consequently, D#/Eb (UT#9/-3) and Bb (UT-7) can be attributed with *g*9 and *g*10, respectively.

F (UTsus4/11) is absent from the spectra of all CT configurations. Lastly, Db (UTb9) only occurs with WP in the spectra of C3+E3, and NP in the spectra of C3 and the augmented triad. The minimal presence of UTb9 suggests that it can be grouped together with UTsus4/11 as the most distant gravi-tones in the Lydian (#5) GS. Both occupy the space of *g*11-*g*12 and will be represented as *g*11.

*g*1	*g*2			*g*5	*g*6	*g*7	*g*8	*g*9	*g*10	*g*11	
1	3	+5	maj7	T#11	T9	AN13	UT5	UT#9/-3	UT-7	UTb9	UTsus4/11

Example 3.11c: Lydian (#5) *g* values (table).



Example 3.11c cont.: Lydian (#5) *g* values (radar chart).

3.12: The Modular Structure of GSF

It was explained in section '3.2: Gravi-Tone Series Filtering' that GS' are the functions of Gravitonicity. This conception of functionality can be reinforced and developed through a mutually-beneficial analogy to Isabelle Peretz and Max Coltheart's *Modularity of music processing* (2003).

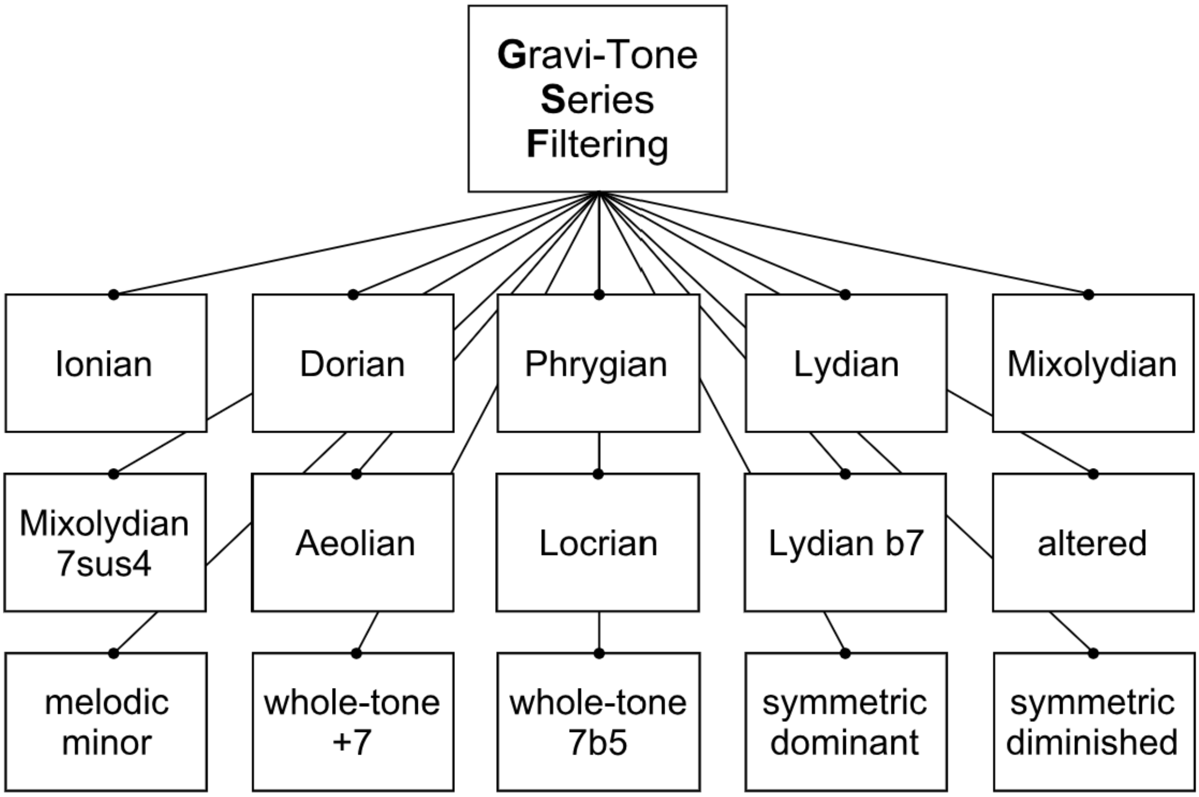
Peretz and Coltheart propose a 'modular model of music processing' (pp. 690) to describe how the neural mechanisms of the brain process music. Their model is comprised of 'music-processing modules' (pp. 689) organised into 'two parallel and largely independent subsystems': 'Pitch organization' (pp. 690) and 'Temporal organization'. Because the processing of GSF deals predominantly with pitch (although not exclusively, as will soon be illustrated with the unified time dimension), only ‘Pitch organization’ is of concern here. The modules housed by the pitch organisation subsystem include ‘Contour analysis’, ‘Interval analysis’, and ‘Tonal encoding’.

According to Peretz and Coltheart, the ‘Tonal encoding’ module is responsible for the ‘hierarchical organization’ (pp, 689) of scales by ‘importance or stability’. This is a reference to the ideas of Carol Kumhansl (2001) and associates, as discussed in section ‘2.6: Tonal Hierarchies’. However, as has been argued by Schoenberg (1978 – originally published in 1911), Hindemith (1941), Russell (1953/2001), Lerdahl (2001), and the preceding pages of Chapter 3, this ‘hierarchy of importance or stability’ (Peretz and Coltheart, 2003, pp. 689) is distance.

Whilst ‘stability’ may be derived from the *g* values (e.g., *g*1 being the most stable, *g*12 being the least), it seems inappropriate to consider the *g* values as a measure of ‘importance’. In Aeolian, for example, ANb13 (*g*7) is not less important than T9 (*g*5). These gravi-tones and their *g* values are simply assuming unique roles as identifying characteristics of the GS. Moreover, the Cambridge Dictionary defines ‘hierarchy’ as ‘a system in which people or things are organised according to their importance’ (Anon, 2021). Because the notion of ‘importance’ resides within the meaning of ‘hierarchy’, it seems equally inappropriate to consider the GS’ as hierarchical.

Through this re-understanding of hierarchical relations as distance, GSF can be offered as a replacement to Peretz and Coltheart’s ‘Tonal encoding’ (2003, pp. 690) module. Additionally, although the ‘Interval analysis’ module goes largely undiscussed in their article, it is conceivable that it may be (at least partially) subsumed by the GSF as interval identification is inherent to understanding the gravi-tones of the GS’.

Furthermore, Peretz and Coltheart propose that the ‘music-processing modules’ (pp. 689) ‘can be composed of smaller processing subsystems that can themselves be referred to as modules' (pp. 688). It can be hypothesised that each GS is a subsystem to the GSF module – as expressed in Example 3.12a. The number of subsystems is equal to the number of GS', i.e., seemingly infinite when accounting for chromatic alterations. However, for ease of representation, Example 3.12a only shows the GS' that were the focus of discussion in section '3.10: Spectral Analysis: *g* values'.



Example 3.12a: The modular structure of Gravi-Tone Series Filtering (GSF). GSF can be offered as a replacement to Peretz and Coltheart's 'Tonal encoding' (2003, pp. 690) module in their proposal for how the brain processes music. It can be hypothesised that each GS is a subsystem to the GSF module. The number of subsystems is equal to the seemingly infinite number of GS'.

The hypothesis that the GS' represent independent modules is supported by three arguments. Firstly, each GS has a unique morphology / genetic code / thumbprint that is articulated by their gravi-tones (interval structure) and *g* values. This individuality is emphasised when it is considered that the *g* values only represent the relative distance order of gravi-tones per GS. In other words, individual *g* values do not translate to the same measure of distance across the GS' e.g., *g*3 feels closer in Ionian (scale degree 3) than melodic minor (scale degree maj7).

Even in similar GS', the distance of an identical gravi-tone and *g* value can be different. For example, despite Ionian and Lydian sharing the same CT's, *g*5 (T9) is seemingly closer in Ionian. This suggests that every gravi-tone in a GS (except for *g*1) is contingent on all others for their relative *and* 'absolute' distance. Arguably, Ionian's AN11 (*g*7) imposes a ceiling that restricts the distance of the closer gravi-tones. Below this ceiling, *g*2-*g*6 (including *g*5 / T9) feel closer. In contrast, the lack of AN ceiling in Lydian enables *g*2-*g*6 to attain a greater distance.

Furthermore, the spacing between the *g* values in each GS does not seem to be equidistant – as expressed in Example 3.12b. In Lydian, for example, *g*6 (T#11) feels a greater spike in distance following *g*5 (T9), than *g*5 does following *g*4 (maj7). Consequently, it can be surmised that each GS has a signature pattern of 'absolute' distance in addition to the relative distance spelled out by the *g* values.

*g*1 *g*2 *g*3 *g*4 *g*5 *g*6 *g*7 *g*8 *g*9 *g*10 *g*11 *g*12

Example 3.12b: Equidistant *g* values.

In future research, it may be possible to chart (qualitatively or quantitatively) the ‘absolute’ distance pattern for each GS and to make comparisons between them – perhaps by conducting experiments with a ‘probe tone method’ (Krumhansl, 2001, pp. 21) (as discussed in section ‘2.6: Tonal Hierarchies’). As the theoretically-appropriate GS for the single tone, it is conceivable that Lydian b7 is the standard-bearer for these ‘absolute’ distance patterns; all twelve of its *g* values may be closer than in other GS’ or they may be the most equidistant. In other words, the ‘absolute’ distance of all other GS’ could represent deviations from that of Lydian b7.

However, this is problematised by equal temperament. Whilst Lydian b7 was attributed to the natural spectra of the single tone, its *g* values – many of which are shared by multiple gravi-tones – were determined from the ‘tempered’ spectra of equal-tempered dominant seventh CT configurations. Consequently, there may be no standard-bearer amongst the equal-tempered GS’, and the pursuit of such a lineage would likely require a non-tempered tuning system. As the (above) discussion of Ionian and Lydian illustrates, however, equal temperament does not rule out comparisons between the GS’.

The uniqueness of the GS’ has been emphasised because it is intrinsically relevant to the second and third supporting arguments for their status as independent modules. The second argument is that, because the GS’ are unique, they are learned individually through our listening experience. This process may be eased by the shared gravi-tones / *g* values of previously learned GS’ (e.g., the CT’s of Dorian, Phrygian, and Aeolian) or encumbered where they differ (e.g., T#11 is *g*6 in Lydian whereas UT#11/b5 is *g*9 in Ionian).

As touched on in section ‘3.10: Spectral Analysis: *g* values’, individuals may have limited or zero knowledge of a particular GS due to a lack of listening experience or it not being used in their part of the world. This can result in an inability to attribute *g* values, particularly for the UT’s. Nevertheless, the sheer number of GS modules suggests that nobody has a ‘complete’ modular structure and that the structure is unique for each person.

Thirdly, whilst GSF may lead to multiple potential GS', their uniqueness suggests that they cannot be attributed simultaneously. For example, section '3.8: Spectral Analysis: GSF for the Single Tone' illustrated that only accounting for the partials of a strong or medium presence (SP's and MP's) would enable the following GS options: Dorian, Phrygian, Mixolydian, Mixolydian 7sus4, Aeolian, Lydian b7, and Lydian b7 (b13). Whilst the present tone would assume *g*1 in any of these GS', the other eleven gravi-tones may not be heard with properties from all GS options e.g., scale degree 6/13/°7 would be T13 and *g*7 in Dorian, UT6/13/°7 and *g*10 in Phrygian, T13 and *g*6 in Mixolydian etc.

Potential exceptions to this 'rule' are the controversial prospects of bi/polytonality and bi/polymodality. Considering the present work, these terms may be collectively redefined as the simultaneous use of two or more GS'. The results of *A perceptual investigation of polytonality* (Thompson and Mor, 1991) 'suggest that listeners can perceive more than one tonal organization or key at the same time' (pp. 70). Moreover, Dmitri Tymoczko (2018) argues that simultaneous GS' may be a perceptual possibility through 'relatively independent auditory streams' (pp. 1) and by interpreting the words of Charles Ives, Alfredo Casella, and Igor Stravinsky.

Research by Carol Krumhansl (2001), however, finds 'Little evidence' (pp. 239) to suggest that simultaneous GS' may be 'perceptually functional as abstract and independent organizational entities'. Therefore, it is also plausible the GS' would 'compete for attention' (Thompson and Mor, 1991, pp. 70) by being alternately attributed or by somehow being fused. This problem merits investigation in future research.

3.13: Modularity and Functionality

This section will illustrate how the modular structure of Example 3.12a offers a potentially unifying perspective on the functionality of modality, tonality, 'the new modalism' (Vieru, 1993, pp. 16), blues, and even atonality. Each of these functional relationships were historically contextualised in section '1.2: The Evolution of Harmony in Western Music'.

Pieces within a single mode draw upon a single GS module. According to Isabelle Peretz and Krista L Hyde (2003), even 'infants are perceptually equipped for assimilating the music pitch structure of any culture' (pp. 362). This suggests that the ability to learn any GS module is a biological 'universal' (Peretz, 2006). Therefore, if the required GS module has been learned, any piece using a single mode can be universally understood.

The functional relationships of tonality, blues, and 'the new modalism' (Vieru, 1993, pp. 16) are constructed through the sequential arrangement of multiple GS modules (functions) with specific fundamentals / *g*1's. The historic transition from modality to tonality was attained by subordinating the modes to the major and minor keys. However, this did not mean a gross reduction or streamlining of the available GS modules (modes). Instead, they 'continued to exist on limited spaces, adapting chameleonically' (Vieru, 1993, pp. 16).

To clarify this, *The Chord Scale Theory & Jazz Harmony* (Nettles and Graf, 1997) makes a further significant contribution to this research. The text offers a comprehensive account of how chord scales (now understood as GS modules) are mapped to the harmonic contexts of tonality, modality, blues, and so-called 'nonfunctional relationships' (pp. 162). These potentials are represented by scale degrees within a system of Roman numerals that, unlike 'Extended roman' (Taylor, 2005, pp. xiii), is all upper case. This is because the chord quality is realised following the numeral.

Reflecting the CT's of the chord scales / GS', most numerals are represented as seventh chords. However, as has become clear through the first two qualities of GSF (present tone(s) and their harmonic spectra), a seventh chord is not a pre-requisite for GS attribution – even a single present tone is sufficient. Nettles and Graf explain that diatonic chords 'use the diatonic scales associated with the displacement of the Ionian scale' (1997, pp. 33):

Imaj7: Ionian

II-7: Dorian

III-7: Phrygian

IVmaj7: Lydian

V7: Mixolydian

V7sus4: Mixolydian 7sus4

VI-7: Aeolian

VII-7b5: Locrian

Such numerals have historically hidden the GS' that construct tonality in deference to the major and minor keys as the great organisers. For example, using the mapping above, it can be identified that the succession of D Dorian, G Mixolydian, and C Ionian would be reductively acknowledged as II-7 / V7 / Imaj7 in C major. Whilst it is true that the individual GS modules 'continued to exist on limited spaces' (Vieru, 1993, pp. 16), they are no less essential to the tonal system. The authority of the major and minor scales is only granted by the sequential arrangement of the GS modules. Despite their reductive nature, the numerals are included in this research to be consistent with Nettles and Graf's work as a system for GS attribution.

Nettles and Graf's system is extensive and goes far beyond diatonic harmony, showing how: Neapolitan Sixth chords can be understood as bIImaj7 chords with a Lydian b7 GS; likewise, any type of bVI7 augmented sixth chord (Italian / French / German) would be attributed with a Lydian b7 GS; diminished seventh chords have a complex array of GS'; and that 'where symmetry exists, nonfunctional relationships usually exist' (pp. 162). The entirety of this system has been compiled in the 'Appendix: The Attribution of GS' in Functional Relationships'. It is not essential for the reader to study the Appendix closely, but it will be a helpful reference tool to accompany the analysis of Chapter 4.

Whereas individual GS modules can be universally learned and understood, the facility for hearing the functional relationships between them takes a greater degree of learning. Peretz and Robert J Zatorre (2005) write that 'the acquisition of harmonic hierarchy appears to emerge later in development' (pp. 93), citing work by Trainor and Trehub (1992). They also cite research by Koelsch et al. (2003) to state that 'by the age of five, the degree of harmonic appropriateness of chord progression appears assimilated' (Peretz and Zatorre, 2005, pp. 93).

As a result, listeners with insufficient listening experience of a particular functional relationship may 'incorrectly' attribute GS'. For example, section '3.9: Spectral Analysis: GSF for Tempered PT Combinations' illustrated that Lydian is the theoretically-appropriate GS for a major seventh chord. This is in accordance with the first two qualities of GSF: present tone(s) and their harmonic spectra. However, memory traces of preceding tones (third quality of GSF) have the potential override the harmonic spectra. If D Dorian and G Mixolydian were to precede a C major seventh chord, then the listener with experience of the tonal system would attribute a C Ionian GS.

For the listener who lacks this experience, the third quality of GSF may have no bearing on the C major seventh chord. As a result, they may attribute a C Lydian GS. Likewise, if an A dominant seventh chord were preceded by E Dorian, the experienced listener of tonal music would attribute an A Mixolydian GS. By contrast, the inexperienced listener may attribute the GS that correlates most strongly with the spectra of the dominant seventh chord. Judging from the harmonic spectra of Example 3.7c, this would still be A Mixolydian.

Beyond the established types of functional relationship, it is the belief of this work that the infinite complexity of GS module combinations – each with twelve possible fundamentals / *g*1's – is reason for humility at our current stage of harmonic exploration in the equal-tempered system. Since the dawn of 'the new modalism' (Vieru, 1993, pp. 16), composers have used GS modules individually (as in the earlier modality), but also used them sequentially to construct new functional relationships.

Herbie Hancock's *Cantaloupe Island* (1964), for example, features a repeating 16-bar pattern with four bars each of F Dorian, Db Lydian b7, D Dorian, and F Dorian. This combination of GS modules does not reflect any type of established functional relationship. Consequently, during the first cycle of the pattern, GSF only attributes GS' based on the present tones and their harmonic spectra. In repeat cycles, however, the pattern of GS modules becomes encoded in the listener's memory as a functional relationship. It seems likely that this knowledge can be carried beyond the end of the piece and deployed whenever else the same functional relationship is heard.

In contrast to any type of functionality, atonal music effectively disables the modular structure of Example 3.12a. The bears similarity with how AN's can lead to the GSF module questioning its output (attributed GS), as discussed in section '3.5: Upper Tensions'. In atonality, however, the GSF module can quickly become largely or entirely redundant. To illustrate this effect, Example 3.13a shows the opening of Arnold Schoenberg's *Drei Klavierstücke, Op. 11 (Three Piano Pieces (1909))* (1999).

Example 3.13a: The opening of Arnold Schoenberg's *Drei Klavierstücke, Op. 11 (Three Piano Pieces (1909))* (1999).

The piece begins with a single tone, B. As discussed in section '3.8: Spectral Analysis: GSF for the Single Tone', B Lydian b7 would be the theoretically-appropriate GS but many others remain as options. Factoring in the G# that follows: if B is *g*1, G# is a 6/13/°7 interval; if G# is *g*1, B is a -3/#9 interval. In both cases, there are many potential GS'. Regardless, the G that shortly follows brings complications. At this point, it is reasonable to consider either B or G as *g*1 because they are the highest and lowest tones that also opened and closed the phrase. However, neither the interval structure with B as *g*1 (B = 1, G = +5/b13, G# = -7) or G as *g*1 (G = 1, G# = b9, B = -3/#9) clearly indicate a common GS.

In contrast to these speculations, the chord in bar two offers Gb as *g*1. Moreover, its interval structure (Gb = 1, F = maj7, B = sus4/11, G = b9) epitomises the challenge to GSF. The combination of maj7 and sus4/11 would seem to indicate either an Ionian or melodic minor

GS. However, neither of these GS' feature b9 as a T. It might be argued that b9 is a chromatic alteration, or even a UT, but the present tones do not clearly represent either GS. The 3 (Bb) and -3 (A) CT's are initially missing for Ionian and melodic minor, respectively, and B would bring its own challenge to both as AN11.

After several bars of such challenges, it seems that the GSF module understands the general futility of its attempted processing and becomes inactive. Without GSF, the tones are no longer gravi-tones: they do not carry the meaning of distance (*g* values) or motion. This is particularly evident as the number of tones increases (e.g., from beat three in bar four), although processing may briefly resume as the tones decrease (e.g., bar nine). It might be concluded that atonality is the intentional challenging and/or disabling of the GSF module.

Finally, the discussion of Fred Lerdahl's (2001) and Carol Krumhansl's (2001) respective works in Chapter 2 showed that there are three types of distance: 'the relative proximity of pcs' (Lerdahl, 2001, pp. 45) (pitch classes); 'the relative proximity of chords within a region' (within a key); and 'relative proximity among tonal regions' (between keys). This research has been and remains focused on the former. However, in future research, the modular structure of Example 3.12a may represent a route to an alternative understanding of the second and third distance types.

Lerdahl and Krumhansl's focus on key centres pre-supposes a tonal relationship between the GS'. This does not account for other types of functional relationship or, crucially, the GS' as independent modules. Where no functional relationship exists, it may be that: (1) there is perceivable (and perhaps quantifiable) distance between the seemingly infinite array of all GS' with twelve potential *g*1's; or (2) there is no perceivable distance for a GS beyond its own *g* values. The second would suggest that functional relationships are a requirement to perceive distance between the GS'.

3.14: GS Subsets and 'Exotic' Scales

This section will address scales other than the chord scales of the GS' and their chromatically altered versions. Firstly, à la pitch-class set theory, each GS may be regarded as a set that contains subsets. The first two rows of Example 3.14a show the *g* values and gravi-tones of Aeolian (randomly selected), as presented in section '3.10: Spectral Analysis: *g* values'. The three subsequent rows illustrate subsets drawn from the CT/T/AN/UT organisation: the chord scale subset omits the UT's, the CT's and T's subset additionally omits ANb13, and the CT's subset only includes the gravi-tones of the minor seventh chord.

By extension, a subset may be formed by any combination of gravi-tones. Even a lone fundamental / *g*1 may represent a subset if the corresponding GS is supplied by the harmonic spectra (e.g., Lydian b7) or memory traces of preceding tones. Although perhaps most prevalent in rock and blues, pentatonic scales are a popular means of deriving subsets in many styles of music. These are usually major (e.g., in C = C D E G A) or minor (C Eb F G Bb) but others are possible, as evidenced by the 'Dominant 7th Pentatonic' (pp. 9) (C D E G Bb) in Steve Khan's *Pentatonic Khancepts* (2002).

In Example 3.14a, the rows following the CT's subset illustrate how pentatonic minor scales built upon each gravi-tone of the Aeolian chord scale generate different subsets. As Khan's text documents, the subsets generated by pentatonic minor scales built upon gravi-tones 1 (C = 1, Eb = -3, F = T11, G = 5, Bb = -7), T11 (F = T11, Ab = ANb13, Bb = -7, C = 1, Eb = -3), and 5 (G = 5, Bb = -7, C = 1, D = T9, F = T11) are all diatonic to the Aeolian chord scale.

Subsets with more distant gravi-tones can be unlocked by rooting the pentatonic minor scales on other scale degrees, so long as the GS is sufficiently well-defined. A scale rooted on ANb13 (Ab in C Aeolian), for example, would highlight -3 (*g*4), ANb13 (*g*7), UTb9 (*g*8), UTmaj7 (*g*8), and UT#11/b5 (*g*10). For practitioners, such 'Gravitonic Pentatonics'

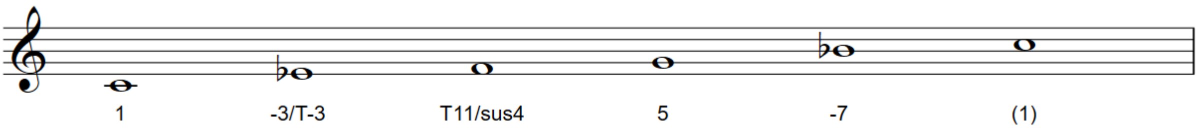
(Gravitonic = relating to Gravitonicity) may represent an exciting access point to fresh harmonic conquests through familiar finger patterns or compositional tendencies.

Aeolian	*g*1	*g*2	*g*3	*g*4	*g*5		*g*7	*g*8		*g*10		
	1	5	-7	-3	T9	T11	ANb13	UTb9	UTmaj7	UT3	UT#11/b5	UT6/13/°7
chord scale	✓	✓	✓	✓	✓	✓	✓					
CT's and T's	✓	✓	✓	✓	✓	✓						
CT's	✓	✓	✓	✓								
pent. minor (1)	✓	✓	✓	✓		✓						
pent. minor (-3)			✓	✓			✓	✓			✓	
pent. minor (5)	✓	✓	✓		✓	✓						
pent. minor (-7)			✓	✓		✓	✓	✓				
pent. minor (T9)	✓	✓			✓	✓						✓
pent. minor (T11)	✓		✓	✓		✓	✓					
pent. minor (ANb13)				✓			✓	✓	✓		✓	

Example 3.14a: Subsets (left column) of the Aeolian GS. The ticks in each row indicate the gravi-tones / *g* values that are present in the corresponding subset. In the left column, the gravi-tones following each 'pent. minor' (pentatonic minor) indicate the scale degree from which they are built e.g., pent. minor (5) = G pentatonic minor in C Aeolian.

The pentatonic minor scale rooted on the fundamental may represent a subset of Aeolian, Dorian, or Phrygian. However, for the hypothetical listener with no knowledge of these GS', how would *g* values be apportioned to a pentatonic minor scale context? The method for deriving *g* values in section '3.10: Spectral Analysis: *g* values' was to observe the spectra of each chord scale's CT's. Whereas scales may be accompanied by directions for their general use, the harmonic information rarely delineates CT's and T's, very rarely AN's, and seemingly never UT's.

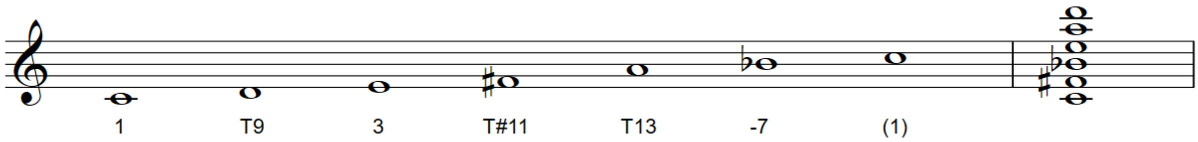
This is problematic because an identical pitch collection may result in a fundamentally different GS, as demonstrated by Mixolydian and Mixolydian 7sus4. Similarly, Example 3.14b demonstrates how the pentatonic minor scale (shown in C) may contain two chord scale formulations.



Example 3.14b: Two chord scale formulations of a C pentatonic minor scale.

Equivalent to the 'Pent. Minor (1)' subset in Example 3.14a, the first formulation reflects the gravi-tones of Aeolian, Dorian, and Phrygian: 1, -3, T11, 5, -7. In place of Eb, F may also assume the mantle of a CT: 1, T-3, sus4, 5, -7. It is also conceivable that G (5) and Bb (-7) may lose their CT status, although unlikely given their presence in the spectra of the single tone (see the first table of Example 3.7c). The CT's would be contextually determined by the four qualities of GSF. Once they are clear, the spectral analysis can be undertaken to determine the *g* values of the CT's, T's, and UT's.

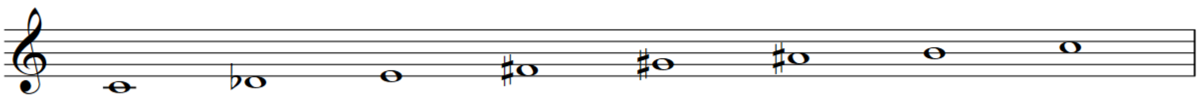
Similarly, more 'exotic' scales may represent equivalent or subset pitch collections of a chord scale within a GS systematised in section '3.10: Spectral Analysis: *g* values' or a chromatically altered form. Example 3.14c demonstrates a subset with the so-called 'Prometheus scale' (bar one), as drawn from Alexander Scriabin's 'mystic chord' (bar two).



Example 3.14c: The 'Prometheus scale' (bar one), as drawn from Alexander Scriabin's 'mystic chord' (bar two).

Analysing the chord in isolation, GSF would clearly attribute Lydian b7: it contains six of the seven gravi-tones in the Lydian b7 chord scale; the 'missing' present tone (5) would have a strong presence as a harmonic of the fundamental, as identified during the spectral analysis; and, as identified in section '3.8: Spectral Analysis: GSF for the Single Tone', Lydian b7 is the theoretically-appropriate GS for the single tone. Because the Prometheus scale is an X axis expression of the 'mystic chord', the component tones share their CT and T functions with Lydian b7 – as Example 3.14b shows. As a result, the Prometheus scale may be regarded as a subset of Lydian b7.

Like the pentatonic minor scale, such ‘exotic’ scales may contain multiple context-specific CT/T/AN formulations. An example with historical notoriety is the so-called ‘Enigmatic scale’ (shown in Example 3.14d), ‘apparently originally published as a “puzzle” in Ricordi’s *Gazzetta musicale de Milano*’ (Balthazar, 2004, pp. 180).



Example 3.14d: The ‘Enigmatic scale’.

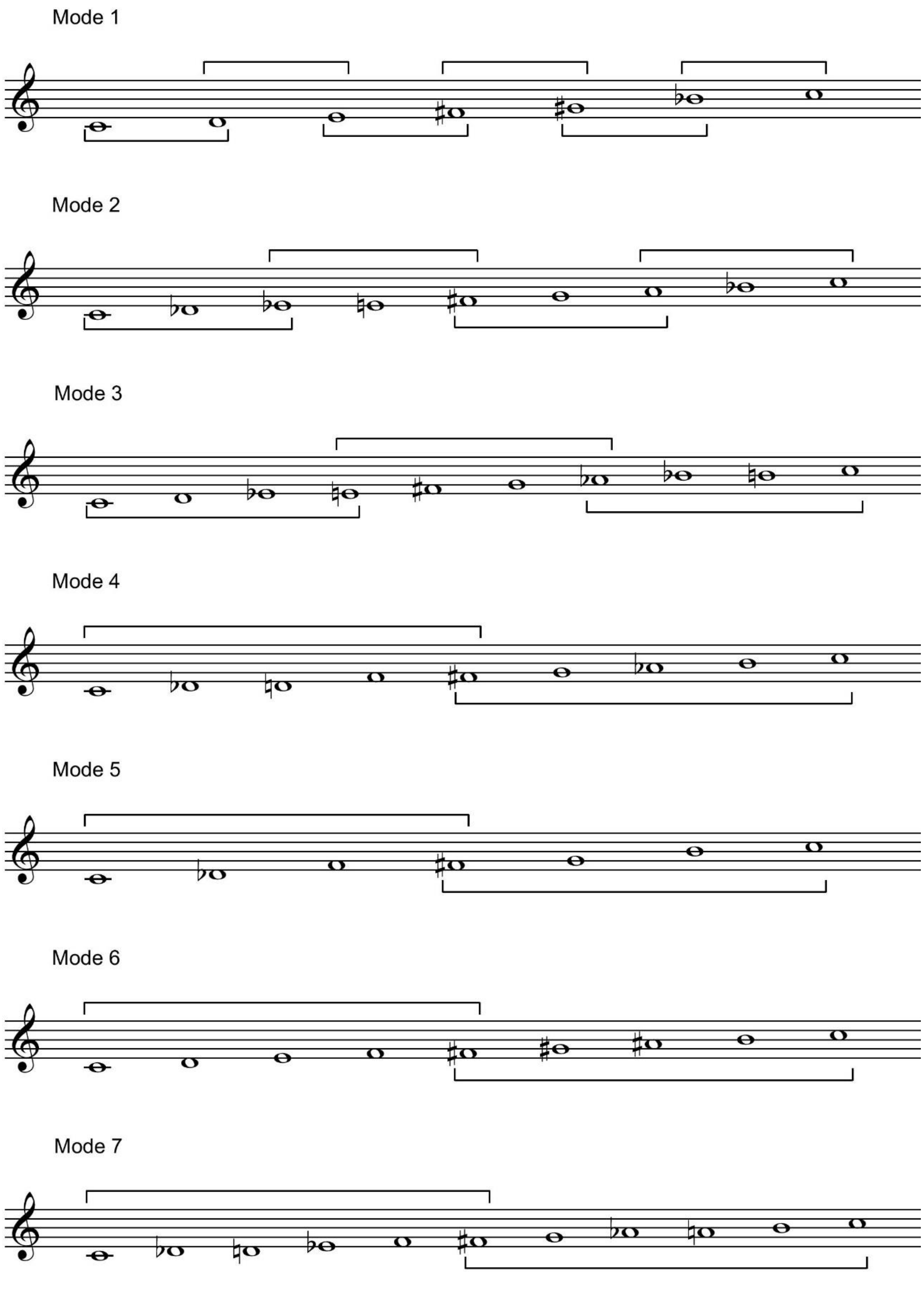
Whilst the major third (E) is unchallenged, there are two candidates for the fifth (F#/Gb = b5, G# = +5) and seventh (A#/Bb = -7, B = maj7). If maj7 is a CT, then F#/Gb would likely be understood as T#11 in a chromatically altered Lydian GS: 1, ANb9, 3, T#11, +5, T#13, maj7. The unusual ‘#13’ – forced by the equally unusual number of consecutive semitones (A#-B-C-Db) – is used in place of -7 to emphasise that maj7 is the CT. In the company of maj7, is it also feasible that b5 is functioning as a CT: 1, ANb9, 3, b5, Tb13, T#13, maj7. Further possibilities can be unlocked with -7 as a CT. If -7 and b5 are CT’s, the chord scale resembles whole-tone 7b5 with a flattened ninth: 1, Tb9, 3, b5, Tb13, -7, AN/UTmaj7. Similarly, if +5 is a CT, the chord scale resembles whole tone +7 with a flattened ninth: 1, Tb9, 3, T#11, +5, -7, AN/UTmaj7.

Whereas the maj7 CT results in ANb9, Tb9 is due to the ‘inherent instability’ (Nettles and Graf, 1997, pp. 27) of dominant seventh chord scales – as noted in section ‘3.4: The Chord Scale Theory’. B represents an interesting problem in both formulations with -7 as a CT.

Arguably, it may be heard as ANmaj7 if ‘built into’ the diatonic environment / chord scale with sufficient melodic and/or harmonic usage. However, given the consecutive semitones in the scale, it is perhaps more plausible that B would be functioning as UTmaj7. The inclusion of this pitch in the scale may reflect chromatic intentions for the melody, not unlike the bebop scales in jazz. Such melodic use of UT’s will be identified in the analysis of Chapter 4.

The same logic may be applied to Olivier Messiaen’s ‘Modes of Limited Transpositions’ (1956, pp. 58) (shown in Example 3.14e) from *Technique de mon langage musical* (1944) (transl. *The Technique of My Musical Language* (1956). As Messiaen explains,

> Based on our present chromatic system, a tempered system of twelve sounds, these modes are formed of several symmetrical groups, the last note of each group always being common with the first of the following group. At the end of a certain number of chromatic transpositions which varies with each mode, they are no longer transposable […] It is mathematically impossible to find others of them, at least in our tempered system of twelve semitones. (1956, pp. 58)



Example 3.14e: Olivier Messiaen's 'Modes of Limited Transpositions' (1956, pp. 58).

Mode 1 (the whole-tone scale), for example, contains six symmetrical groups of two notes (indicated by the brackets) and can only exist in two transpositions e.g., whole-tone scales built on C, D, E, F#/Gb, G#/Ab, and Bb contain the same pitches, as do whole-tone scales built on C#/Db, Db/Eb, F, G, A, and B. Likewise, mode 2 contains four symmetrical groups and can exist in three transpositions e.g., C, C#/Db, and D roots would generate different pitch collections, whereas C, D#/Eb, F#/Gb, and A roots would generate the same. Mode 3 contains three symmetrical groups and can exist in four transpositions and, finally, modes 4-7 all contain two symmetrical groups and can exist in six transpositions.

In accordance with the GS', Messiaen writes that the modes 'can be used melodically, and especially harmonically'. Furthermore, he demonstrates a keen awareness that the modes (GS') construct functional relationships: 'They are at once in the atmosphere of several tonalities, *without polytonality*, the composer being free to give predominance to one of the tonalities or to leave the tonal impression unsettled'; they may also be 'opposed to or mixed with' (pp. 67) 'the three great modal systems of India, China, and ancient Greece' and 'atonal music'.

However, Messiaen does not provide harmonic information to accompany the 'Modes of Limited Transpositions' (1956, pp. 58) in Example 3.14e. Judging by the following statement, this is because Messiaen also recognises each mode as a scale with 'diatonic' harmonies (perhaps the source of their own modal systems and functional relationships): 'One can begin the scale on the second degree; […] but that changes nothing in the chords created by the mode' (pp. 59). Therefore, each of Messiaen's modes may be regarded to comprise GS' equal in number to their component tones (not accounting for different chord scale formulations) e.g., mode 7 may be developed into ten GS'.

Mode 1 has already been systematised with the root (C) as *g*1 / 1 into two chord scale formulations: whole-tone +7 and whole-tone 7b5. Due to the perfectly symmetrical interval structure, an exciting quirk of the whole-tone scale is that every GS in its 'modal system' may also be whole-tone +7 or 7b5 e.g., C whole-tone +7 or 7b5 is related to the same GS' rooted on D, E, F#/Gb, G#/Ab, and Bb. Another chord scale formulation of mode 1 called altered (♮9) will be systematised in Chapter 4.

With the root (C) as *g*1 / 1, mode 2 has likewise already been systematised as symmetric dominant. Moreover, the 'mode' built from the second degree (Db) of mode 2 has been systematised as symmetric diminished. Due to the alternating half and whole steps of mode 2, the remaining 'modes' / GS' alternate symmetric dominant and diminished e.g., Eb symmetric dominant, E symmetric diminished, F# symmetric dominant etc. It is likely that other chord scale formulations are also possible for mode 2.

The GS' corresponding to the root of modes 3-7 are all chromatically altered and with varying numbers of UT's. Mode 5, for example, may be used as a subset (omitting 3) of Ionian maj7sus4 (1, sus4, 5, and maj7 CT's) – a GS that will be encountered in Chapter 4 – with a b9 alteration and UT#11/b5. Not unlike the 'Enigmatic scale', mode 3 contains two CT candidates for the third (Eb / -3 and E / 3) and seventh (Bb / -7 and B / maj7). For example, -3 and -7 as CT's may suggest Aeolian (#11) with UT3 and UTmaj7, whereas 3 and -7 as CT's may suggest Lydian b7 (b13) with UT#9/-3.

The same process may be used to identify the remaining multitude of GS' that correspond to the roots of modes 3-7 and all their component scale degrees. Moreover, there exists a deeper project in uncovering the potential functional relationships that may bind them together and how these are 'opposed to or mixed with' (pp. 67) other functional relationships.

3.15: Memory and Time (T Axis)

The third quality of GSF (memory traces of preceding tones) has been shown to exert considerable influence on determining *g*1'(s) and constructing functional relationships. These discussions assumed the memory traces to be immediately accessible, without finer consideration of the omni-present time dimension (T axis). This section will outline three 'tools' for analysing how GSF is influenced by memory and time, addressing: (1) a delay in GSF's processing; (2) memory constraints on the number of present tone(s); and (3) long-term mental representations across a piece.

Because 'much about musical memory still remains to be understood, indeed, explored' (Snyder, 2018, pp. 176), the materials presented in this section should not be considered as a systematic exposition of how memory and time influence GSF. Rather, each 'tool' represents an additional step towards deciphering GSF's full complexity. The three 'tools' discussed in this section will be drawn upon as required in the analysis of Chapter 4.

In accordance with the CST conception of functionality, it was stated in section '3.2: Gravi-Tone Series Filtering' that the GS' (the output) are 'instantly' (Nettles & Graf, 1997, pp. 30) justified by 'our sub-conscious'. However, in practice, GSF's processing seemingly operates with a slight delay. This reflects GSF's mapping to the 'delay' component of the 'feed-forward' (Gordon, 1995, pp. 185) 'filter' in Example 3.2a.

In section '3.3: Identifying *g*1', Example 3.3f showed the bass and piano riff of Miles Davis' *So What* (1959b). The present tones alone are sufficient for GSF to attribute a D Dorian GS – but at what point is this confirmed? During the first cycle of the riff, the duration of each tone (quavers at 136bpm) means that they are succeeded before GSF can take the necessary time to analyse their spectra. For example, the first tone (D) could be attributed any potential GS for the single tone, with Lydian b7 being the most theoretically-appropriate.

However, before GSF can analyse the spectra of the single tone, it is succeeded by A. Whilst this reduces the potential GS options somewhat, it also ‘interrupts’ GSF by changing the present tones and arguably problematises *g*1 identification.

Whilst it is difficult to pinpoint when the Dorian GS may be attributed, it is logical to hypothesise that: the more present and preceding tones (first and third qualities of GSF) that support a particular GS, the less processing is required of the spectra (second quality) and, consequently, the shorter GSF’s processing.

Therefore, GSF’s processing time is decreased as the *So What* riff progresses. The present tones of the bass part (D = 1, E = 9, G = 5, A = 6/13/°7, C = -7) could correspond to four GS’: Dorian, Mixolydian, Mixolydian 7sus4, and Lydian b7. Arguably, because GSF’s processing time decreases with each tone – and because Lydian b7 naturally correlates with the spectra of the single tone – the attribution of D Lydian b7 becomes more likely throughout the riff. This attribution is ‘corrected’ to Dorian for each subsequent cycle with the F (-3) in the second piano chord.

In addition to the delay in spectral processing, there is seemingly a more basic delay to GSF. Example 3.15a shows a phrase from *Koljo* (Shufflebotham, 2020c), an arrangement of a Macedonian folk song in 9/8 (quaver-note = 230bpm). The phrase is harmonised with four sequential dominant chords (Bb7, Eb7, Ab7, Db7), with the Eb7 and Ab7 connected by two additional chords through constant structure. Definitions of ‘sequential dominant’ and ‘constant structure’ can respectively be found in sections A.2.3 and A.8.2 of the Appendix.

Example 3.15a: An excerpt from *Koljo* (Shufflebotham, 2020c).

The longer duration and functional relationship of the sequential dominant chords (only the latter in the case of Eb7) means that they are easily processed by GSF. However, the fleeting duration of E7 and Gb7 and their lesser functional importance within the sequential dominant progression, means that GSF seemingly faces a greater challenge in processing them. This points to there being a universal delay in GSF processing that restricts GS attribution beyond a certain tempo of harmonic rhythm i,e the rate at which the GS' are attributed.

The second 'tool' is an understanding of how memory constraints on the number of tone(s) can influence GSF. Anatol Vieru (1993) offers 'modal density' (pp. 50) as a solution to this problem. 'Modal density' is the number of 'elements' (present tone(s)) 'represented in a modal zone' (tones to which a single GS may be attributed):

you can move more freely in a music built of 5 elements than in one of 9 elements. On the other hand, a zone of 9 elements can give us more information than one of 5 elements. This ratio between the power of analysis and the information capacity (the increasing of one implies the decreasing of the other) reflects the property of any mode to include and be included in other modes.

An important distinction between a 'modal zone' and a GS is that the former is concerned only with its present 'elements' / tones, whereas the latter houses *g* values for all twelve gravi-tones. However, GSF is similarly influenced by the 'ratio between the power of analysis and the information capacity'. To illustrate this, Example 3.15b shows a chord which GSF – based on present tones alone – would attribute with a Dorian GS: C-7(13/**3**). Following the directions of section '3.6: Chord Symbols', UT3 is printed in bold.

Example 3.15b: C-7(13/**3**).

If the chord were to be sounded indefinitely, then the Dorian GS would likewise continue indefinitely. However, if the chord were sounded for its written duration but the listening was to continue indefinitely, then the memory traces of the present / preceding tones and their attributed GS would progressively ‘decay with time’ (Deutsch, pp. 285). Although the longevity of the GS through the silence is indeterminate, it might be hypothesised that: the more present / preceding tones there are to be remembered, the greater the challenge to GSF’s processing / ‘power of analysis’ (Vieru, 1993, pp. 50) and, consequently, the faster a GS may slip from memory.

By this logic, the longest memory trace would be of a single tone and its attributed GS, whereas the shortest would be of a chord structure with all twelve tones. Because it contains six tones, the chord in Example 3.15b falls between these extremes. It might also be hypothesised that: the lower the *g* values (closer to *g*1), the longer the memory trace; the higher the *g* values (closer to *g*12), the shorter the memory trace. Consequently, it could be the case that GSF is reiterated as the individual gravi-tones slip from memory in order of UT’s, T’s, AN’s, and CT’s. This would ultimately leave *g*1 of the original GS (e.g., C Dorian in Example 3.15b) to be processed by GSF as a single tone.

Of course, GS’ are not always attributed to tones as convenient Y axis simultaneities. To illustrate that the ‘power of analysis’ hypotheses are also pertinent to X axis phenomena, Example 3.15c shows an arpeggiated version of the chord in Example 3.15b. In addition to the number (density) of the present / preceding tones, the X axis brings time between the successive tones. If Example 3.15c were to be played at a tempo of 300bpm, then the six tones would be comfortably attributed with the Dorian GS. If it were played at 1bpm, then GSF would be focused on each tone as a separate entity, perhaps with some consideration of the preceding tone as they are changed.

Example 3.15c: Arpeggiated C-7(13/**3**).

However, if the tempo were to be raised to 20bpm, then the memory trace of C may initially persist as *g*1 to the subsequent tones but be lost on those later in the passage, from which alternative *g*1's and GS' may be identified. To summarise, GSF's 'power of analysis' is increasingly challenged by the greater the number of present tones, the higher the *g* values of the present tones, and the more time by which they are separated. This discussion of the second tool has focused on the 'information capacity' of present tone(s) and memory traces of preceding tones: the first and third qualities of GSF. It should, however, be considered that the harmonic spectra (second quality) and unified time dimension (fourth quality – yet to be discussed) may bring their own complications.

The third and final 'tool' is an understanding of how long-term mental representations influence GSF across a piece. An effective and accessible means of framing these representations is Iréne Deliége and Marc Mélen's theory of 'cue abstraction' (1997, pp. 395): 'units of memory may be created by any strikingly distinctive features in the surface of the music (called *cues*) over a range of time spans […] these cues act as memory markers that define larger segments of music' (Snyder, 2018, pp. 174). There are two types of 'cue' that can have long-term influence on GSF: (1) inputs to the GSF module that are attributed with a single GS, and (2) patterns of multiple GS'.

If the first type resurfaces multiple time (perhaps as part of a form) and/or has been sounded recently, then its familiarity can accelerate GSF's processing. For example, it might be assumed that Example 3.15c's C Dorian GS is attributed by the A (T13) on the fifth beat. Upon repeat hearings, however, the recognition of the phrase as a 'cue' may accelerate the processing e.g., perhaps by the Eb (-3) on the second listening, the Bb (-7) on the third etc.

The second type of 'cue' can be identified by reducing a piece (or excerpts / sections of) to the attributed GS', their respective *g*1's, and their harmonic rhythm. This might be thought of as a chord chart in which the symbols have been generalised to GS names. As with the first type of cue, the resurfacing of the second can accelerate GSF processing. For example, GSF's second quality (harmonic spectra) will be more active with patterns of GS' that do not correspond to established functional relationships e.g., D Phrygian, G Mixolydian, C Lydian. However, upon repeat hearings, the recognition of the 'cue' / newly established functional relationship will accelerate GSF's processing by requiring less from its second quality.

Both types of 'cue' may persist through differentiation of various musical parameters e.g., timbre, dynamics, rhythm, tempo, GS etc. The same phrase or pattern of GS' could be sounded with a difference of timbre and still be recognised as a 'cue'. Contrastingly, too much differentiation may result in GSFs processing taking place as the usual or even slower rate.

According to Deliége and Mélen, 'a further function of the cues is to generate abbreviations of self-organised units which reduce the amount of information to be stored in memory' (pp. 395). Whilst there are two main types of GSF-influencing cue presented here, they are not distinct from each other. The first type may function as 'abbreviations' of GS progressions as 'self-organised units'. In other words, an individual excerpt of tones that incurs a single iteration of GSF may act as a cue for a whole progression of subsequent GS', thus reducing the processing time for all GS'.

3.16: The Unified Time Dimension (Z Axis)

The first three qualities of GSF – present tone(s), their harmonic spectra, and memory traces of preceding tones – are the core determinants of its processing. However, further detail and nuance can be unlocked via its fourth quality: the Z axis. In geometry, the Z axis is the third dimension (following X and Y) and corresponds to depth. Whilst three dimensions (X/Y/T) have framed GSF thus far, the understanding of music notation remains 2D e.g., X and T run in parallel. Therefore, where and what is the 'depth' / Z axis of the score and, in turn, Gravitonicity?

In the article *How Time Passes* (1959, pp. 10), Karlheinz Stockhausen makes the following observation about our perception of music:

> Our sense-perception divides acoustically-perceptible phases into two groups; we speak of *durations* and *pitches*. […] Until a phase-duration of approx. 1/16", we can still hear the impulses separately; until then, we speak of 'duration' […] Shorten the phase-duration gradually to 1/32", and the impulses are no longer separately perceptible […] one perceives the phase-duration as the 'pitch' of the sound.

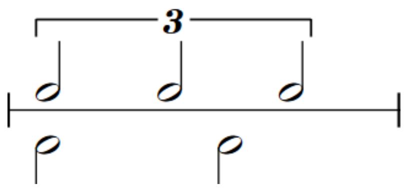
In a thorough examination of Stockhausen's article, Christopher K Koenigsberg describes it as 'controversial' but 'a turning point in the history of 20th-century compositional theory' (1991, pp. 1). Stockhausen's dense and sometimes-incorrect use of acoustic vocabulary such as 'phase(s)' has been scrutinised (Backus, 1962; Koenigsberg, 1991), and his observation has since been scientifically fleshed out and challenged with greater acoustic and psychoacoustic detail (Backus, 1962, pp. 167; Koenigsberg, 1991, pp. 3-12; Gordon, 1995, pp. 1059-1061). Nevertheless, the identified frequency (Hz) relationship between pitch and duration remains perfectly valid.

It is this relationship, incurring part of what Stockhausen would later characterise as 'a unified time domain' (1989, pp. 95), that affords Gravitonicity with a covert Z axis: the unified time dimension. As the preceding pages of the RQ2 methodology have systematically detailed, each GS contains twelve gravi-tones (intervals) that are represented by the CST scale degree numbering system. To bring greater clarity to the frequencies involved, each gravi-tone can also be represented by an interval ratio. Example 3.16a shows the interval ratios (and cents) for each gravi-tone in equal temperament and, for reasons which will be explained shortly, just intonation. The figures were taken from Peter A Frazer's *The Development of Musical Tuning Systems* (2015).

Gravi-Tones	Equal Temperament		Just Intonation	
	Ratios	Cents	Ratios	Cents
1	1:1 / $1:2^{12/12}$	0 / 1200	1:1 / 2:1	0 / 1200
b9	$1:2^{1/12}$	100	16:15	111.73
9	$1:2^{2/12}$	200	9:8	203.91
#9/-3	$1:2^{3/12}$	300	6:5	315.64
3	$1:2^{4/12}$	400	5:4	386.31
sus4/11	$1:2^{5/12}$	500	4:3	498.04
#11/b5	$1:2^{6/12}$	600	45:32	590.22
5	$1:2^{7/12}$	700	3:2	701.96
+5/b13	$1:2^{8/12}$	800	8:5	813.69
6/13/°7	$1:2^{9/12}$	900	5:3	884.36
-7	$1:2^{10/12}$	1000	9:5	1017.60
maj7	$1:2^{11/12}$	1100	15:8	1088.27

Example 3.16a: The interval ratios (and cents) of the gravi-tones in equal temperament and just intonation.

The interval ratios are fundamental to the unified time dimension. For example, a perfect fifth interval in just intonation has a ratio of 3:2; if scale degree 5 were 60Hz, then scale degree 1 would be 40Hz. These frequencies can be doubled / halved to be raised / lowered by an octave with no change to the interval ratio e.g., 90Hz : 60Hz, 45Hz : 30Hz, 27.5Hz : 15Hz, 13.75Hz : 7.5Hz etc. The last of these crosses the frequency threshold from pitch to duration and results in a polyrhythm (hemiola), as shown in Example 3.16b.



Example 3.16b: Just intonated perfect fifth interval (3:2) as a polyrhythm.

Likewise, each of the other interval ratios in Example 3.16a represent unique polyrhythms when the frequencies are low enough to become durations. The core hypothesis of the unified time dimension (Z axis) is that GSF processes these polyrhythms as their pitched equivalents and similarly attributes them with *g* values. Example 3.16c illustrates the tripartite mapping of *g* values, gravi-tones, and interval ratios (potential polyrhythms) for the Lydian GS.

The ratios / polyrhythms in Example 3.16c correspond to the just intonation tuning system (as laid out in Example 3.16a), in which all intervals correspond to whole number ratios. These whole number ratios are more representative of polyrhythms that will appear in practice than the irrational-number ratios of equal-temperament. For example, Lydian's T#11 (*g*6) has respective ratios of 45:32 and $1:2^{6/12}$ for just intonation and equal temperament. Whilst both polyrhythms are rare in any kind of repertoire, the latter is only likely conceivable with electronic assistance. By contrast, just intonated polyrhythms such as 3:2 (scale degree 5), 4:3 (sus4/11), and 5:4 (3) are varyingly commonplace.

*g*1	*g*2	*g*3	*g*4	*g*5	*g*6	*g*7	*g*8	*g*9	*g*10	*g*11	
1	5	3	maj7	T9	T#11	T13	UT+5/b13	UT-7	UT#9/-3	UTb9	UTsus4/11
1:1	3:2	5:4	15:8	9:8	45:32	5:3	8:5	9:5	6:5	16:15	4:3

Example 3.16c: the tripartite mapping of *g* values, gravi-tones, and interval ratios (potential polyrhythms) for the Lydian GS.

An arguable problem with mapping the just intonated ratios to the *g* values is that the methodology for deriving the latter was based on equal temperament. Nevertheless, like 'out-of-tune' pitches in equal-tempered contexts, it seems likely that the just intonated polyrhythms are perceptually 'rounded' to their nearest equally-tempered gravi-tone. Theoretically, this should be easier when the just-intonated ratio is closer to its equal-tempered equivalent. Example 3.16a shows that scale degrees 5, sus4/11, and 9 are all within five cents, thus making them easier to 'round'. Contrastingly, being 17.6 cents higher in equal temperament, scale degree -7 would be the most difficult.

Unlike the present tone(s), their harmonic spectra, and memory traces of preceding tones, the extent of the unified time dimension's influence on GSF is generally unclear. It is possible that this quality does not even require pitch. For example, if 5:4 (scale degree 3), 15:8 (maj7), and 45:32 (#11/b5) polyrhythms were played by non-pitched instruments, could GSF attribute a Lydian GS? Or would the lack of a single pitch mean that GSF remains inactive?

The problems multiply when GSF's other qualities are simultaneously engaged. If a present tone is added to the previously non-pitched polyrhythm context, then it will become *g*1.

However, the rest of the GS is unclear – would the unified time dimension or the harmonic spectra take command? The former would result in Lydian whereas the latter suggest Lydian b7 as the most theoretically-appropriate. Memory traces of preceding tones could bring further complications.

It can also be considered that the polyrhythms may be sounded by the intervals they are inferring e.g., with C as *g*1, a 16:15 polyrhythm with Db and C as the upper and lower voices. In this case, GSF's fourth quality (the Z axis) would reinforce its first (present tone(s)), perhaps to the detriment of qualities two (harmonic spectra) and three (memory traces of preceding tones).

However, it is more likely that the polyrhythms will be sounded by intervals that they do not infer e.g., whilst the 3:2 polyrhythm corresponds to a perfect fifth interval, it may not be sounded by scale degrees 1 and 5 of a GS. For example, in a context with a C Lydian GS, the 3:2 polyrhythm could be sounded by D (T9) and A (T13). Despite G's absence as a present tone, the 3:2 polyrhythm may be sufficient to infer it.

The preceding paragraphs have hopefully demonstrated that GSF's fourth quality is something of an enigma. Because of its shadowy complexity, the unified time dimension (Z axis) will be drawn upon selectively in the analysis of Chapter 4.

3.17: Distance and Motion: RMS and AMS

The RQ2 methodology began with an analogy to Sir Isaac Newton's Universal Law of Gravitation (1687). It was argued that each of the gravi-tones embody two types of 'mass' or significance: distance and motion. Distance, it was explained, would be of this research, which may offer an opportunity to better understand motion in future research. This potential opportunity is lightly framed here. To understand how motion and distance might interact, it is helpful to consult Albert Einstein through the most famous equation in physics (1905) – shown in Example 3.17a.

$$E = mc^2$$

Example 3.17a: Einstein's (1905) mass-energy equivalence. 'E' indicates energy, 'm' – as with Newton's Law – refers to mass, and 'c^2' is the speed of light squared.

The associated meaning of the 'E' and 'm' components (c^2 is not needed here) is succinctly summarised by the cosmology writer Marcus Chown (2017, pp. 111-112):

> mass and energy are aspects of the same thing. […] Mass, it turns out, is merely another form of energy, like sound energy or heat energy or electrical energy. […] It is a fundamental feature of the world that one form of energy can be converted into another form. […] But Einstein's $E = mc^2$ formula can be read both ways. Not only is mass a form of energy but energy has an effective mass. Any type of energy. […] crucially, so does energy of motion. So a body has an intrinsic mass – universally known as its 'rest mass' – but it also possesses mass due to its motion.

The distinction between ‘rest mass’ and ‘mass’ accrued by motion is the key. However, there is a fundamental difference between the rest mass of physical gravitation and that of Gravitonicity. Whilst any physical object at rest exerts attraction in proportion to its mass, the gravi-tones do not. There is no attraction (or repulsion) embodied by the gravi-tones / *g* values of a GS. The *rest mass significance* (hereby RMS) of Gravitonicity is purely distance.

In addition to their RMS, the gravi-tones can accrue additional ‘mass’ / significance from motion. This occurs through their contextual implication in the ‘three melodic forces’ (pp. 2) of Steve Larson’s *Musical Forces* (2012 – reviewed in Chapter 2). For example, in Larson’s analysis of “Twinkle, Twinkle Little Star” (see Chapter 2), the gravi-tones ‘C, E, and G – the members of the tonic triad’ (pp. 88) gain ‘mass’ / significance through their role as ‘melodic attractor(s)’ (pp. 89). In contrast to the dormant, background presence of the RMS (i.e., the attributed GS), the ‘mass’ / significance brought by the ‘three melodic forces’ may be given the collective label of *active mass significance* (AMS).

The discussion of the RMS (the four qualities of GSF) was framed by the X, Y, Z, and T axes. However, it might be considered that Gravitonicity is not restricted to these dimensions. An area of physics called ‘string theory’, or ‘superstring theory’, speculates that we are existing in ‘ten-dimensional space-time – nine dimensions of space and one of time’ (Chown, 2017, pp. 202). Within these dimensions, the ‘graviton’ (Rothman & Boughn, 2008) – the hypothetical quantum of gravity that is appropriated in this work as the ‘gravi-tone’ – is theorised to have a quality that makes it unique from the other fundamental particles of the universe: ‘it is free to move […] and explore the ten-dimensional ‘bulk’’ (Chown, 2017, pp. 207).

Akin to the graviton, it might be envisaged that the gravi-tones are similarly able to journey from the RMS dimensions (X/Y/Z/T) into a set of AMS dimensions where they accrue ‘mass’ / significance from motion. If Larson’s ‘three melodic forces’ (Larson, 2012, pp. 12) are conceived of as dimensions, ‘musical gravity’ (pp. 82) could be cast as the G dimension, ‘melodic magnetism’ as the M dimension, and ‘musical inertia’ as the I dimension. This totals seven dimensions: X/Y/Z/T/G/M/I.

At the outset of his work, Larson makes the caveat that ‘I do not claim that gravity, magnetism, and inertia are the only forces that shape melodic expectations’ (pp. 3). This suggests that more AMS dimensions may await, potentially matching or going further than ‘ten-dimensional space-time’ (Chown, 2017, pp. 202).

Precisely how the RMS (distance) and the AMS (motion) dimensions interact is left for future research. It may be that the AMS dimensions converge with the RMS, potentially boosting or attenuating specific *g* values of a GS. On the other hand, the *g* values of the RMS and the qualities of the AMS may be fundamentally separate. The argument for the GS’ development as independent modules of the brain (see ‘The Modular Structure of GSF’) favours the second of these hypotheses.

Finally, Larson framed and analysed the ‘three melodic forces’ (2012, pp. 2) with an intuitive understanding of CST, i.e., without ‘a complete specification of the theory’ (pp. 118). He conceived of the distance as a ‘hierarchical nesting’ (pp. 117) in which ‘the chromatic scale provides motion through the more stable “parent” chord-scale, which in turn provides motion through the more stable chord’.

The RMS presented in this research may represent a renewed opportunity for understanding the ‘three melodic forces’ (pp. 2) for two reasons. Firstly, the ‘nests’ have been comprehensively delineated as the GS’ and their attribution by GSF. Secondly, whereas Larson’s understanding of distance only had three levels (‘chromatic scale’ / ‘chord-scale’ / ‘chord’ (pp. 117)), the *g* values of each GS represent up to twelve levels.

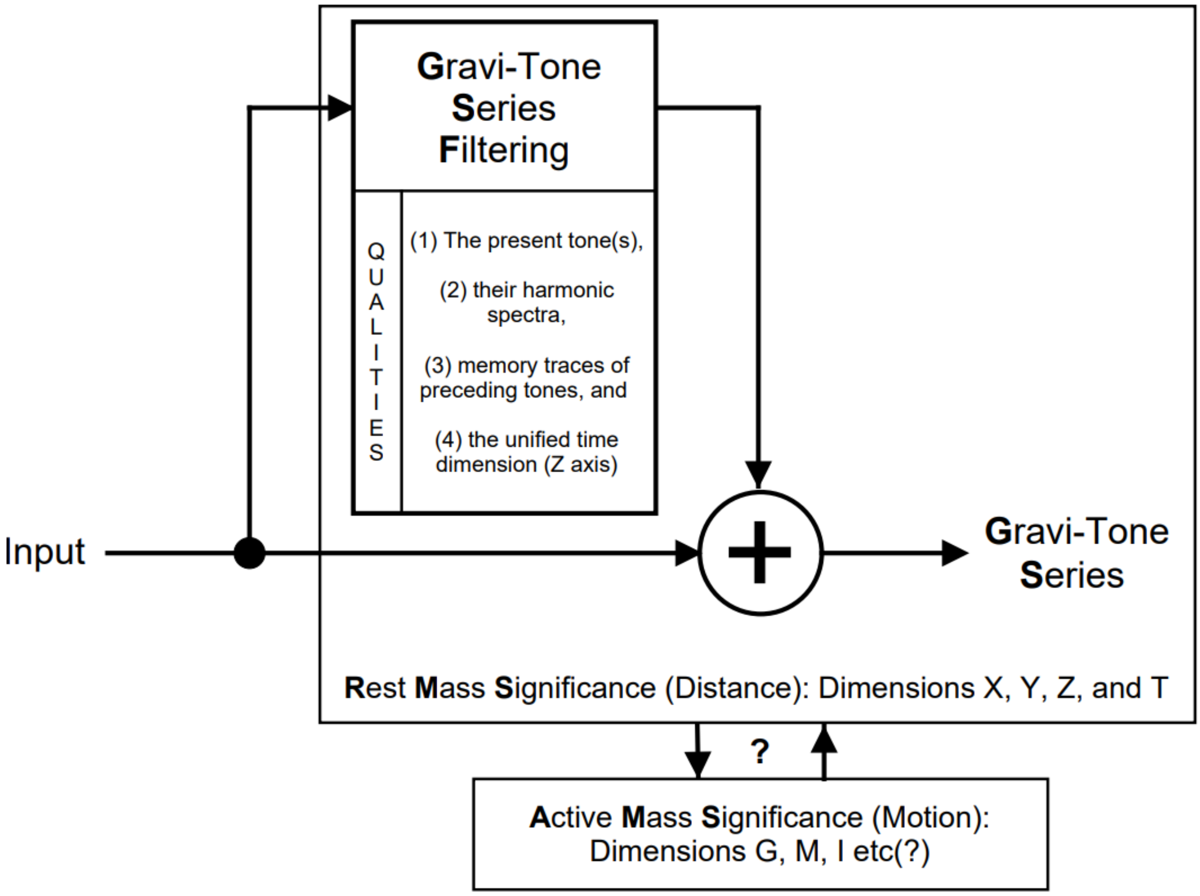
3.18: The Neutral Level Model of Gravitonicity

The final step of the RQ2 methodology was to collectively represent the theoretical tools as a 'neutral level' (Nattiez, 1990, pp. 12) model of Gravitonicity. This is shown in Example 3.18a. Because Gravi-Tone Series Filtering is the heart of the model, Example 3.18a appears as an extended version of Example 3.2a. An explanation of GSF as a 'feed-forward' (Gordon, 1995, pp. 185) 'filter' can be found alongside the earlier example. This includes definitions of the 'Input', the 'delay' process of 'Gravi-Tone Series Filtering' itself, and the 'Gravi-Tone Series' as the 'Output'.

Unlike Example 3.2a, the 'neutral level' (Nattiez, 1990, pp. 12) model includes the four qualities that GSF analyses: (1) **the present tone(s)**, (2) **their harmonic spectra**, (3) **memory traces of preceding tones**, and (4) **the unified time dimension (Z axis)**. As illustrated by the preceding pages, the numbering of the qualities is purely for referential convenience (e.g., GSF's second quality) and does not reflect their order of operation or relative importance – both of which are context-specific.

The process of GSF and its output (a GS) are encompassed by the label 'Rest Mass Significance' (RMS), as discussed in the previous section. This underlines the purpose (distance) and dimensional habitats (X/Y/Z/T) of these components. Likewise, the 'Active Mass Significance' (AMS) label distinguishes motion and its dimensional habitats (G/M/I etc(?)) from the RMS.

Finally, in the title of this thesis, the word 'towards' is included for two reasons. Firstly, it remains uncertain how the distance and motion interact. This uncertainty is represented in Example 3.18a by two arrows facing alternate directions and a question mark between the RMS and AMS. Secondly, 'towards' is an acknowledgment that GSF may not have been completely deciphered. It is plausible that any of the four qualities may require more attention, particularly in the case of the Z axis. Moreover, it is equally plausible that GSF comprises further qualities that are waiting to be discovered.



Example 3.18a: The 'neutral level' (Nattiez, 1990, pp. 12) model of Gravitonicity. As in Example 3.4, Gravi-Tone Series Filtering (GSF) is mapped onto the 'feed-forward' (Gordon, 1995, pp. 185) 'filter' diagram from *The Computer Music Tutorial*. The 'Input' (sound) is analysed by the four qualities of GSF (the 'delay' process) leading to the 'Output': a Gravi-Tone Series (GS). This process is encompassed as the 'Rest Mass Significance' (RMS), indicating the purpose (distance) and dimensional habitats (X/Y/Z/T) of these components. The RMS is connected to the Active Mass Significance (AMS / motion) and its dimensions (G, M, I etc(?)) but precisely how they interact is left for future research.

3.19: Research Questions 1 and 3

The research questions stated earlier were as follows:

> **RQ1**: What is Gravitonicity?
>
> **RQ2**: How and to what extent is it possible to derive a model of Gravitonicity from the 'neutral level' (Nattiez, 1990, pp. 12)?
>
> **RQ3**: How does the listener construct the meaning (Nattiez's 'esthesic dimension') of Gravitonicity and to what extent can this lead to a subjective experience?

In response to RQ2, the preceding pages of Chapter 3 have developed a 'neutral level' model of Gravitonicity. With the 'neutral level' model in place, the next stages of the methodology were to bring responses to RQ1 and RQ3. The response to RQ1 will use conceptual metaphor theory (Lakoff and Johnson, 1980; 1999) in explanation of the 'distance' (Rest Mass Significance) and 'motion' (Active Mass Significance), lightly drawing upon Steve Larson's *Musical Forces* (2012) for the latter.

The RQ3 response will extrapolate the subjective experience ('esthesic dimension' (Nattiez, 1990, pp. 12)) of Gravitonicity by drawing upon John Shepherd and Peter Wicke's 'Semiological model' (1997, pp. 173). It will be discussed how the construction of meaning can lead to different experiences of Gravitonicity 'in different individuals and in the same individual at different times' (pp. 175). The discussion will contextualise both the 'neutral level' (Nattiez, 1990, pp. 12) model and application of metaphors in our construction of meaning, ultimately producing the full model of Gravitonicity.

3.20: Conceptual Metaphor

Summarising the core of George Lakoff and Mark Johnson's conceptual metaphor theory (1980; 1999), Steve Larson's *Musical Forces* (2012) argues that:

> if metaphors help us to understand new things in terms of familiar things, then those familiar things will tend to belong to source domains that are more basic in our experience. And our most basic experiences are physical. (pp. 48)

In a chapter co-authored with Mark Johnson, Larson details the metaphor 'Musical Succession Is Physical Motion'. They argue that 'basic experiences of physical motion give rise, via metaphor, to the chief ways in which we conceptualize and experience musical motion' (pp. 61). In other words, our 'intuitive embodied understanding' (pp. 82) of the analogous physical forces metaphorically informs and shapes our experience of 'melodic gravity', 'melodic magnetism', and 'musical inertia'. Each of these forces were illustrated in Chapter 2 with Larson's analysis of "Twinkle, Twinkle Little Star".

With the embodiment explanation of the 'motion' (AMS), Larson's work brings a partial response to RQ1 ('What is Gravitonicity?'). To complete the response to RQ1, conceptual metaphor theory can also be used to explain the 'distance' (RMS) of Gravitonicity. We understand this 'distance', as expressed by the *g* values, through our 'intuitive embodied understanding' of 'Spatial-Relations Concepts' (Lakoff and Johnson, 1999, pp. 30):

> Spatial-relations concepts are at the heart of our conceptual system. They are what make sense of space for us. They characterize what spatial form is and define spatial inference. But they do not exist as entities in the external world. We do not see spatial relations the way we see physical objects. We do not see nearness and farness. We see objects where they are and we attribute to them nearness and farness from some landmark.

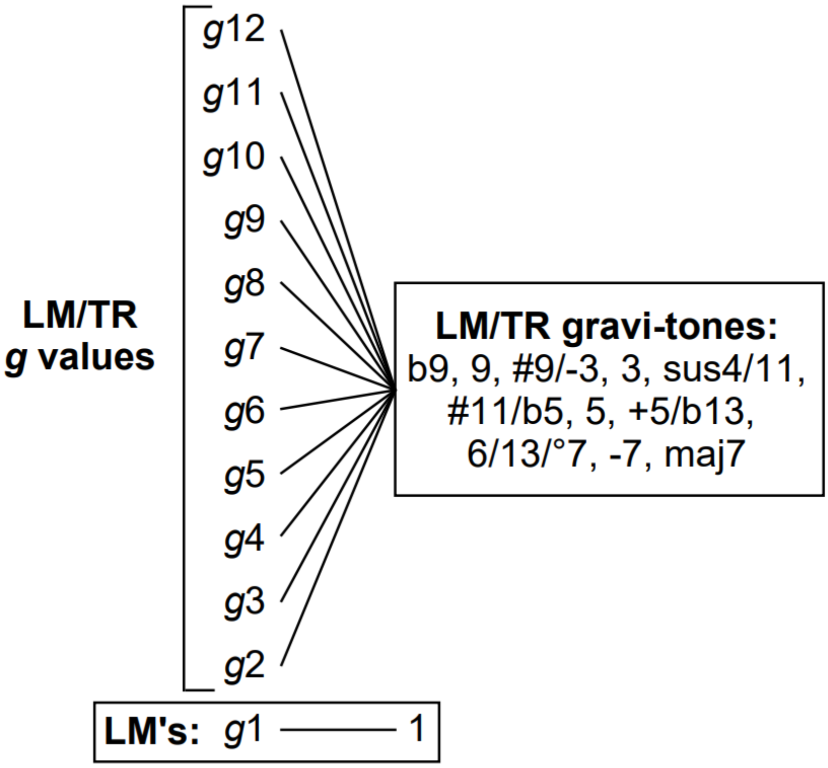
Lakoff and Johnson state that 'there is a relatively small collection of primitive image schemas that structure systems of spatial relations in the world's languages' (pp. 35) and give the following examples: 'part-whole, center-periphery, link, cycle, iteration, contact, adjacency, forced motion (e.g., pushing, pulling, propelling), support, balance, straight-curved, and near-far'.

Distance is an entailment of all these examples with varying degrees of clarity e.g., 'part-whole' implies distance within a part or between the parts that comprise the whole; a 'link', 'contact', or 'adjacency' between two objects implies distance between and across them. If there is space, there must be distance. This is supported by Lakoff and Johnson's reference to 'nearness and farness' in their (above) introduction to 'Spatial-Relations Concepts' (pp. 30).

We understand spatial relations (and therefore distance) by projecting a 'container schema (a bounded region in space' (pp. 31)). This consists of 'a profile that highlights the interior of the schema', 'a structure that identifies the boundary of the interior as the landmark (LM)', and the object overlapping with the interior as a trajector (TR)'. To demonstrate, the text uses the example '"Sam is in the house," the house is the landmark (LM) relative to which Sam, the trajector (TR) is located'.

Container schemas may be ‘physically instantiated’ or ‘conceptually imposed’ as a ‘bounded region in space’. A cup, for example, has the clear physical boundaries (landmarks / LM’s) of sides, a handle, and a base. Any contents (hot chocolate, cream, marshmallows etc.,) may be understood as trajectors (TR’s), or even as landmarks in their own right e.g., the cream acting as a boundary between the marshmallows and liquid. Like the cup, a basketball court is physically instantiated by markings on the ground. However, as we understand the markings to define boundaries through the air above, it is also conceptually imposed.

In addition to visual scenes (e.g., the basketball court), container schemas may also be conceptually imposed upon ‘our motor movements’ and – pertinent to Gravitonicity – ‘something we hear’. The GS’ are container schemas that we conceptually impose upon what we hear to perceive the ‘distance’ / RMS. As Example 3.20a shows, the ‘profile that highlights the interior of the schema’ / GS is defined by the gravi-tones and their corresponding *g* values as landmarks (LM’s).



Example 3.20a: The Gravi-Tone Series' (GS') as 'Container schemas' (Lakoff and Johnson, 1999, pp. 32). For each GS, the gravi-tones and *g* values define the 'profile that highlights the interior' as landmarks (LM's). Across GS', the unique mapping of gravi-tones onto *g* values and their distinctive spacing enable all but *g*1 / scale degree 1 to be recognised as trajectors (TR's).

Within each GS, the gravi-tones and *g* values are not trajectors (TR's). This is because their mapping becomes fixed as the appropriate GS module of the brain develops, as discussed in section '3.12: The Modular Structure of GSF'. However, across GS', the unique mapping of gravi-tones onto *g* values and the distinctive spacing of the latter (also discussed in section 3.12) enable both to also be recognised as TR's. This is true of all gravi-tones and *g* values except for *g*1 / scale degree 1, which has the same mapping in any GS.

But to what extent does Example 3.20a resemble the experiential reality? By isolating the GS' as container schemas from the broader musical experience, it may be that Example 3.20a neglects intervening thought-patterns and imagery from other attributes e.g., motion, timbre, dynamics etc. Alternatively (or in addition), it may be that, whilst the *g* values of Example 3.20a represent our experience of pitch distance, their portrayal in our mind's eye bears no visual similarity.

However, the conscious recognition of pitch distance seemingly necessitates thinking that may also reveal our unconscious experience. As we try to recognise the relative distances of the gravi-tones, we cannot help but project the GS container schemas onto physically instantiated container schemas. For example, because it houses the ears for listening and the brain for understanding, listeners may commonly project the GS schemas onto their own heads.

The projection of the GS schema onto a physical schema raises interesting questions about orientation and position. Should the GS schema be projected vertically (as in Example 3.20a), horizontally, or diagonally? Because *g*1 corresponds to the fundamental tone / bass and *g*2-*g*12 are therefore understood as above it, it seems logical that the GS schemas would commonly be oriented vertically. Therefore, for the mapping onto the listener's head, *g*1 could be positioned at the jaw whilst *g*12 would be the top of the head. A horizontal orientation, on the other hand, might position *g*1 at one ear and *g*12 at the other, or g*1* at the tip of the nose and *g*12 at the back of the head.

Moreover, the GS schemas need not occupy the whole of a physical schema. The vertical orientation, for example, could position *g*1 in the centre of the head with *g*12 at the top. It is intriguing to consider that the space used of a physical schema or the size of the schema itself may have implications for how *g* values are perceived. Could it be that the mapping onto half instead of the whole physical schema might make the space between *g*1-*g*12 feel contracted?

In addition to the size of a physical schema potentially adjusting the space between *g*1-*g*12, it might also be considered that the unique landmarks (LM's) of each schema could contract or expand individual *g* values. If two different listeners vertically projected GS schemas onto their own heads (*g*1 / chin, *g*12 / top of head), then their unique physical features may result in contracted or expanded *g* values. For example, if eye-level corresponds to *g*7 for both listeners, then the listener with a higher eye-line may experience a more distant *g*7.

Because we construct the meaning of pitch distance, it is logical that similar physical schemas are selected to amplify our individual experience. Some common examples may include: the heart of the listener as the romanticised locus of emotion / feeling; the whole body of the listener, perhaps in pursuit of an 'out of body' experience; and, if understood with some physical form, the ontological whole of the listener's present existence. Nevertheless, GS schemas could be projected onto anything that has a physical presence in the world e.g., other individuals, crowds of people, buildings, land, oceans, planet earth, the solar system etc.

The sound-source may lead us to elect one of these physical schemas over another. For example, if listening through headphones, then the head of the listener might seem the most likely. Or if a speaker is the sound-source at the opposite end of a room, then the GS schemas may be projected horizontally between the speaker and listener.

Physical schemas are also likely chosen because of what we can see in each moment. For example, if listening from a beach whilst looking at the sea and towards the horizon, *g*1 may be where the listener stands, *g*2-*g*11 as the sea, and *g*12 as the horizon. Alternatively, if the listener is attending a live performance, then the GS schemas may be projected onto the room e.g., *g*1 as the listener's position, *g*12 as the ceiling, *g*2-*g*11 as identifiable landmarks such as speakers, individuals in higher seating, patterns or symbols on the walls etc.

Lastly, it can be considered that we visualise ‘physical’ container schemas as we construct meaning from music. When listening to Gustav Holst’s *The Planets* (1918), for example, our vision of each planet may represent a physical schema. A country song, on the other hand, may evoke schemas associated with locations in Nashville, NASCAR tracks, or a live performance by Dolly Parton.

3.21: Universality

The distance metaphor that was developed in the preceding section was chosen because of its persistent presence in the literature reviewed in Chapter 2. This historic recognition, in combination with the embodied nature of spatial-relations concepts, permit the reasonable assumption that the ‘distance’ of Gravitonicity has a significant – if not universal – cultural reach. As a disclaimer to the cultural universality of the ‘Musical Succession Is Physical Motion’ (2012, pp. 82) metaphor, Steve Larson draws upon the work of Richard Dawkins (1976):

> Metaphors are what Richard Dawkins (1976) calls “memes”: mental constructs analogous to genes. Like genes, they live in a particular environment: our thoughts and culture. Like genes, their survival depends on how well they fit in their environment. Thus metaphors are, to an extent, shaped by culture. And, like genes and in an equally circular fashion, they make up part of their environment. Thus culture is simultaneously, to an extent, shaped by metaphors. (Larson, 2012, pp. 48)

Larson concludes that 'we should expect to find that different cultures understand musical motion in different ways' (pp. 317) and closes his work by asking: to what extent is the 'Musical Succession Is Physical Motion' (pp. 82) metaphor 'shared by different cultures, and what differences do the differences make?' (pp. 317). The same argument lends itself as a disclaimer to the potential universality of, what can be coined, the "Pitch Distance is Physical Distance" metaphor, i.e., to what extent is the "Pitch Distance is Physical Distance" metaphor shared by different cultures, and what difference do the differences make?

Both at the levels of culture and individual thought, listeners may embellish their experience of "Pitch Distance is Physical Distance" with other metaphors. For example, a culture or individual may metaphorically map their embodied understanding of distance to relationships e.g., a close friendship or the intimacy of lovers. If this 'Relationship Distance is Physical Distance' metaphor surfaces in the listener's thoughts (either incurred by the piece or extramusical processes), then this may in-turn be mapped to the 'Pitch Distance': "Pitch Distance is Relationship Distance is Physical Distance".

What difference might this embellished meaning make to the experience of Gravitonicity? Firstly, the additional meaning brought by the 'Relationship Distance' metaphor could characterise the distance of the *g* values e.g., *g*1 as the closest of relationships, *g*3 with minor problems to resolve, and *g*12 as bordering on separation. Secondly, and similarly to the effects of projecting GS schemas onto physical schemas, the extra metaphor may potentially contract / expand the *g* values. For example, for the cultures or individuals for which relationship separation has greater poignancy, *g*12 may be experienced as more distant. Likewise, the minor problems may be insignificant to some cultures or individuals, making *g*3 seem closer.

Other embellishing metaphors are identifiable amongst the literature reviewed in Chapter 2. Examples include 'density' (Tomaro and Wilson, 2009, pp. 385), 'hierarchy' (Krumhansl, 2001, pp. 18), and 'tension'. The latter has been absorbed by Gravitonicity through the

‘Tensions’ (T’s) of *The Chord Scale Theory & Jazz Harmony* (Nettles and Graf, 1997) and Miroslav Spasov’s ‘upper tensions’ (UT’s) (Pejovski, 2021 – unpublished manuscript). It can be understood as embellishing the “Pitch Distance is Physical Distance” metaphor with either physical and/or mental/emotional tension e.g., *g*1 as relaxation to *g*12 as maximum strain.

It is unclear how the writers arrived at the embellishing metaphors of density, hierarchy, and tension. These arguably emerged through individual efforts to describe pitch distance without the embodied understanding argument of conceptual metaphor theory (Lakoff and Johnson, 1980; 1999). Instead, being unaware of this argument at the level of culture may have led to consensuses that the writers drew upon.

However, it may be the case that some cultures metaphorically map the quality represented by the *g* values to an alternative type of basic embodied understanding. For example, mapping this quality to our embodied understanding of ‘color concepts’ (Lakoff and Johnson, 1999, pp. 23) would replace what has thus far been understood as distance with colour. Because, like distance, ‘colors do not exist in the external world’, our understanding of the *g* values as colour would be limited to what ‘our bodies and brains have evolved to create’.

Therefore, the meaning (colours) that we would attribute to the *g* values would be drawn from the visible light spectrum e.g., the colour attributed to *g*1 could be violet as it has the lowest visible wavelength. It cannot be stated with any certainty whether such alternative metaphors would neatly substitute for the ‘distance’ or would require a distinct ‘neutral level’ (Nattiez, 1990, pp. 10) model. It might also be considered that such alternative metaphors can be mapped to others for embellishments of meaning, as with “Pitch Distance is Relationship Distance is Physical Distance”. Colour, for example, may be associated with temperature, mood, the changing seasons etc.

In the form of sub-questions to his closing question, Larson offers further disclaimers to the universality of the ‘Musical Succession Is Physical Motion’ (2012, pp. 82) metaphor which can likewise be extended to the Pitch Distance is Physical Distance” metaphor. Two of these questions – to which no answers are proposed here – include: ‘In what musical cultures are sounds heard as *embodied* meanings?’ (pp. 317) and ‘In what musical cultures are sound *heard* as meanings?’.

The former acknowledges space for negotiation over the fundamental idea of conceptual metaphor theory (Lakoff and Johnson, 1980; 1999), that understanding stems from our most basic (namely physical) experiences. Going one stage further, the second question invites us to consider cultures who do not attribute meaning. An account of music devoid of Gravitonicity will be given in the following section, but a listening experience with *no* meaning is more difficult to conceive of.

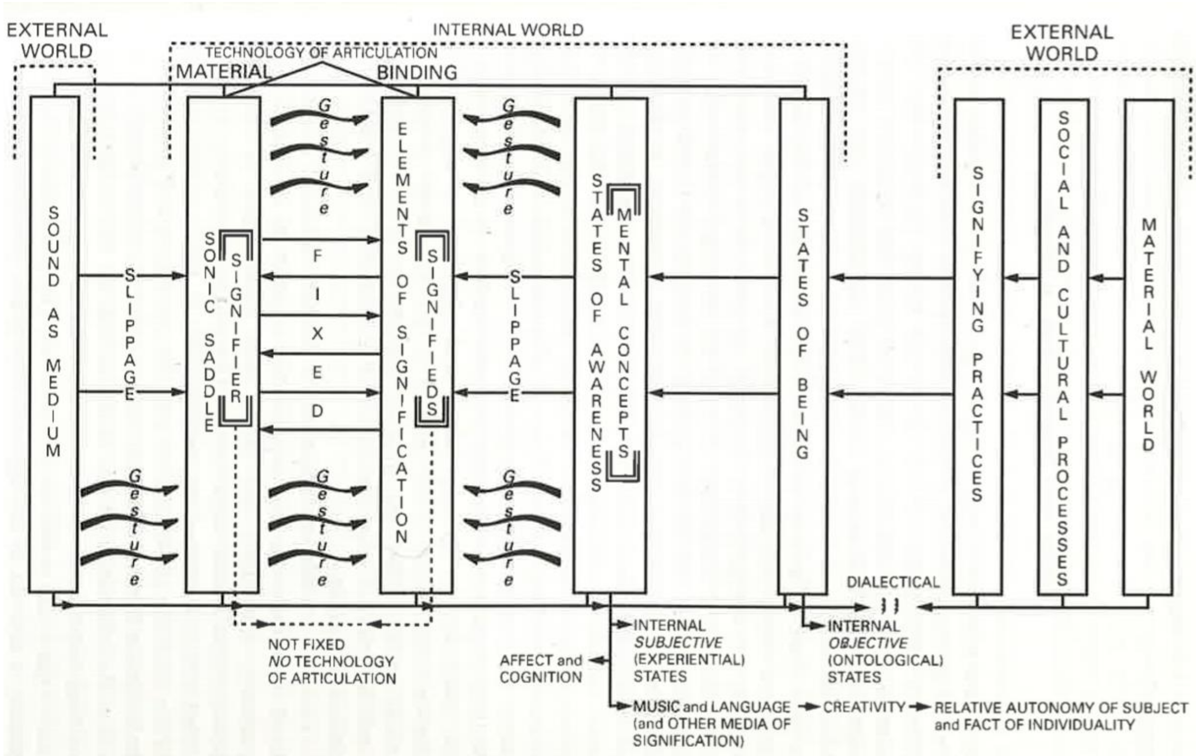
As a final note on metaphor, no argument is made here for how/if the “Pitch Distance is Physical Distance” and ‘Musical Succession Is Physical Motion’ (Larson, 2012, pp. 82) metaphors might interact. Like their potential interaction at the ‘neutral level’ (Nattiez, 1990, pp. 12), this prospect is left for future research.

3.22: The Semiological Model

> Why is thought, being a secretion of the brain, more wonderful than gravity – a property of matter?
>
> - Charles Darwin in his 'C Notebook' (1838) (Barrett et al., 1987, pp. 291)

Semiology was founded on Ferdinand de Saussure's claim that 'the linguistic sign consists of two elements, the *signifier* (the actual phonetic sound) and the object to which it refers, which he called the *signified*' (Beard and Gloag, 2005, pp. 168). This section will draw upon John Shepherd and Peter Wicke's 'Semiological Model' (1997, pp. 173) for music to show how our construction of meaning – the 'esthesic dimension' (Nattiez, 1990, pp. 12) – can lead to a subjective experience of Gravitonicity.

Shepherd and Wicke's 'Semiological Model' is shown in Example 3.22a. At the left of the model, the 'SOUND AS MEDIUM' block represents the 'sounds of music' (pp. 116) that can 'both restrict and facilitate the range of meanings that in any instance can be constructed through them'. Existing in the external world, the sound as medium is equivalent to the 'Input' of the 'neutral level' (Nattiez, 1990, pp. 12) model.



Example 3.22a: Shepherd and Wicke's 'Semiological Model' (1997, pp. 173). This delineates how we construct meaning from the 'SOUND AS MEDIUM' / the 'Input' of the 'neutral level' (Nattiez, 1990, pp. 12) model.

To the right of the 'SOUND AS MEDIUM', the 'SONIC SADDLE' block is the heart of Shepherd and Wicke's model. It represents the gateway to the 'esthesic dimension' and semiological inquiry. Shepherd and Wicke cast the 'sonic saddle' (1997, pp. 159) in place of the linguistic signifier:

> while the saddle of the medium occurs as an aspect of external reality, as the sounds of the auditory time-space of the external world, it is possible to conceive of the sonic saddle *only* as an experiential phenomenon made possible by the medium. (pp. 159-160) […] The signifier has been replaced by the concept of the 'sonic saddle' as the continually unfolding sound-image derived from the medium and *experienced* as the material ground and pathway for the investment of meaning.' (pp. 170)

The 'sonic saddle' (pp. 159) represents the pitches as they are first articulated. However, because it represents the 'pathway for the investment of meaning' (pp. 170), the pitches have not yet acquired their meaning as gravi-tones. This occurs through our experiential application of the "Pitch Distance is Physical Distance" and 'Musical Succession is Physical Motion' (Larson, 2012, pp. 48) metaphors at the 'ELEMENTS OF SIGNIFICATION' block in Example 3.22a.

As explained in section '3.20: Conceptual Metaphor', these metaphors are learned from our embodied understanding of the 'EXTERNAL WORLD' – represented at the right of Shepherd and Wicke's model. By bringing meaning to the pitches as gravi-tones, the 'elements of signification' (1997, pp. 170) assume the role of the linguistic '*signified*' (Beard and Gloag, 2005, pp. 168).

Shepherd and Wicke write that the 'distinction between the experience of the sonic saddle' (1997, pp. 172) – the 'pathway for the investment of meaning' (pp. 170) – and the 'elements of signification' – where the metaphors are attributed – is 'not present in *actual* instances of meaning construction through music' (pp. 172). However, to emphasise the intrinsic presence of Gravitonicity, it is illustrative to consider our experience of music as beginning and ending with the ‘sonic saddle’. In other words, experiencing harmony that is devoid of Gravitonicity.

It is difficult to conceive of functional music in this way e.g., tonality, modality, blues, ‘nonfunctional relationships’ (Nettles and Graf, 1997, pp. 162), and ‘the new modalism’ (Vieru, 1993, pp. 16). As presented to us by the ‘SOUND AS MEDIUM’, the acoustic properties of pitches and intervals would be unchanged. However, without the “Pitch Distance is Physical Distance” metaphor, we would not distinguish order between the pitches. How would the tones of a major triad be perceived? If none of the three tones are recognised as the fundamental / *g*1, what would we hear?

The only route to understanding music without the “Pitch Distance is Physical Distance” metaphor is through the demands of atonality on the GSF module. This was discussed in section ‘3.13: Modularity and Functionality’ with an analysis of Arnold Schoenberg’s *Drei Klavierstücke, Op. 11 (Three Piano Pieces (1909))* (1999). As the combinations and/or saturation of tones challenge the GSF module, its temporary disengagement shows how we hear without the “Pitch Distance is Physical Distance” metaphor. It is advised that the reader reviews the analysis and listens to the piece to appreciate the effect. The experience might be described as unoriented. In anticipation of the GSF module reengaging, the listener simply lets the tones wash over them.

Shepherd and Wicke’s ‘Semiological Model’ (1997, pp.173) is instructive for the experience of Gravitonicity in two further ways: ‘Fixity and Negotiation’ (pp. 174). The writers argue that:

> once sounds are recognized as ‘musical’, a medium is automatically presented and meanings *have* to be invested (otherwise the sounds would not be recognized as ‘musical’). Consequently, there is *no* negotiation possible between meanings as elements of signification and states of awareness on the one hand, *and* the sonic saddle as the *experience* of the medium on the other. In every *particular* instance of meaning creation in music, therefore, *primary* meaning is fixed. (pp. 174)

This ‘fixed’ transmission of meaning is shown in Example 3.22a between the ‘SONIC SADDLE’ and ‘ELEMENTS OF SIGNIFICATION’ blocks. For Gravitonicity, the significant implication is that the metaphors bring meaning to the ‘sonic saddle’ with ‘*no* negotiation possible’. Crucially, therefore, because we share an embodied understanding of spatial-relations concepts, the workings of the ‘neutral level’ (Nattiez, 1990, pp. 12) model of Gravitonicity are the same for an identical ‘SONIC SADDLE’. However, of equal importance, the ‘SOUND AS MEDIUM’ in

> the *external* world cannot completely determine the character of the sonic saddle as the *constructed* and *internal* experience of that medium at any particular moment […] The character of the sonic saddle is arrived at through an editing and interpretation of the medium […] The identical medium can thus give rise to different (although probably similar) saddles in different individuals and in the same individual at different times. (Shepherd and Wicke, 1997, pp. 174-175)

This ‘editing and interpretation of the medium’ is factored into Example 3.22a with two windows for a potential ‘SLIPPAGE’ of meaning: (1) from the ‘SOUND AS MEDIUM’ to the ‘SONIC SADDLE’ blocks, and (2) to the ‘ELEMENTS OF SIGNIFICATION’ from the ‘STATES OF AWARENESS’ that stem from our understanding of the ‘MATERIAL WORLD’.

Although Shepherd and Wicke do not say so explicitly, the former can occur because of our physical perception. No two ears are the same e.g., our ability to hear higher frequencies is lost to varying degrees with age. This may render some pitches inaudible (particularly weaker harmonics) and therefore interfere with Gravi-Tone Series Filtering (GSF). Similarly, the listener’s proximity to the sound source could affect their ability to hear individual pitches, or even hear a piece at all.

For Gravitonicity, the second window of potential ‘SLIPPAGE’ is defined by two factors. The first factor subsumes two experiential properties that were discussed in sections ‘3.20: Conceptual Metaphor’ and ‘3.21: Universality’, respectively: the projection of GS container schemas onto physically instantiated container schemas, and the embellishment of “Pitch Distance is Physical Distance” with other metaphors. The physical schemas and embellishing metaphors that the listener may choose are determined by their knowledge of the ‘MATERIAL WORLD’. These can result in a subjective experience of the *g* values and, thus, a slippage of meaning.

Our evolving listening experience is the second factor. In the RQ2 methodology, it was argued that the GS modules and all types of functional relationship between them (e.g., tonality, blues etc) are learned through listening experience. This knowledge shapes ‘the character of the sonic saddle’ (Shepherd and Wicke, 1997, pp. 174) and thus makes GSF negotiable from person-to-person. Furthermore, given the potential of the ‘sonic saddle’ to change ‘in the same individual at different times’, it can be hypothesised that each individual’s GSF module is in a fluid or continually evolving state.

This fluidity can be recognised through the understanding of long-term memory given in section ‘3.15: Memory and Time (T Axis)’. It was discussed how long-term mental representations are formed across a piece by: (1) inputs to the GSF module that are attributed with a single GS, and (2) patterns of multiple GS’. These representations can now be understood as shaping the ‘sonic saddle’ and thus biasing GSF across the duration of a piece.

It also seems plausible that these representations leave imprints on the ‘sonic saddle’ that shape GSF’s processing of future pieces. The first type of long-term representation would explain why listeners can attribute a single GS when the ‘neutral level’ (Nattiez, 1990, pp. 12) application of GSF leads to multiple options. For example, section ‘3.8: Spectral Analysis: GSF for the Single Tone’ of the RQ2 methodology illustrated that there are multiple GS options. Although Lydian b7 is the most theoretically-appropriate, an individual’s listening experience of what can follow a single tone may lead them to attribute a specific alternative GS.

The second type of long-term representation leaving imprints on the ‘sonic saddle’ (Shepherd and Wicke, 1997, pp. 174) may be an explanation for how functional relationships are learned over time. This would mean that, within the ‘macro-negotiability’ of a listener having / not having experience with each type of functional relationship, there exists a ‘micro-negotiability’ that is specific to each individual’s heard repertoire. In other words, the knowledge of each functional relationship is highly-nuanced because it is contingent on the precise patterns of multiple GS’ that each listener has stored in their long-term memory. Consequently, GS’ determined by functional relationships may be highly-negotiable.

3.23: The Full Model of Gravitonicity

To summarise, Gravitonicity is our experiential application of two metaphors that are based on our embodied understanding of distance and motion in the material world: "Pitch Distance is Physical Distance" and 'Musical Succession is Physical Motion' (Larson, 2012, pp. 48). All arguments and terms covered in sections '3.20: Conceptual Metaphor', '3.21: Universality', and '3.22: The Semiological Model' are expressed in Example 3.23a: the full model of Gravitonicity. Several components have been integrated and/or adapted from Shepherd and Wicke's 'Semiological Model' (1997, pp. 173). The model shows (capitalised terms in inverted commas reflect Example 3.23a):

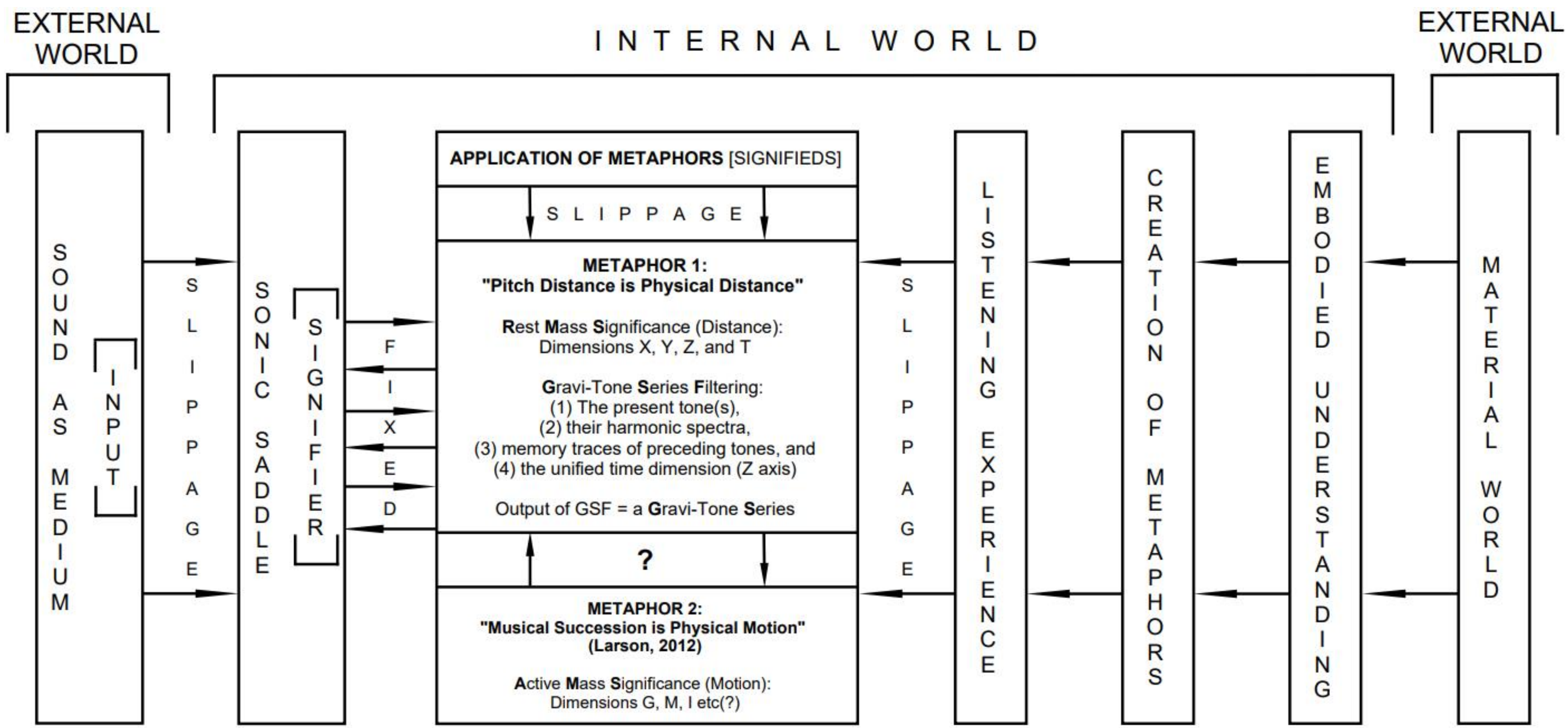
- The 'SOUND AS MEDIUM' (the '[INPUT]' of the 'neutral level' (Nattiez, 1990, pp. 12) model) that can 'both restrict and facilitate the range of meanings that in any instance can be constructed through them' (Shepherd and Wicke, 1997, pp. 173).
- The 'SONIC SADDLE [SIGNIFIER]' as the gateway to our 'INTERNAL WORLD' and 'pathway for the investment of meaning'.
- How our 'CREATION OF METAPHORS' ('METAPHOR 1' and 'METAPHOR 2') is determined by our 'EMBODIED UNDERSTANDING' of the 'MATERIAL WORLD'.
- The 'APPLICATION OF METAPHORS [SIGNIFIEDS]' in place of the more general 'ELEMENTS OF SIGNIFICATION' in Shepherd and Wicke's model (Example 3.22a). 'METAPHOR 1' and 'METAPHOR 2' are, respectively, the RMS (distance) and AMS (motion) of the 'neutral level' (Nattiez, 1990, pp. 12) model produced in response to RQ2. 'METAPHOR 1' has been developed in the preceding pages through 'Spatial-Relations Concepts' (Lakoff and Johnson, 1999, pp. 30) and the 'container schema'

(pp. 31). 'METAPHOR 2' was theorised by Steve Larson (2012). Together, the metaphors bring a response to RQ1: What is Gravitonicity?

- Two arrows facing alternate directions and a question mark between 'METAPHOR 1' and 'METAPHOR 2' to express the uncertainty of how/whether they interact. This problem is left for future research.
- A 'FIXED' / non-negotiable transmission of meaning between the 'SONIC SADDLE [SIGNIFIER]' and the 'APPLICATION OF METAPHORS [SIGNIFIEDS]'. This is because 'once sounds are recognized as 'musical', a medium is automatically presented and meanings *have* to be invested (otherwise the sounds would not be recognized as 'musical')' (Shepherd and Wicke, 1997, pp. 174). Consequently, the workings of the 'neutral level' (Nattiez, 1990, pp. 12) model of Gravitonicity are the same for an identical 'SONIC SADDLE'.
- In response to RQ3, three windows for a potential 'SLIPPAGE' of meaning that can result in a subjective experience of Gravitonicity: (1) from the 'SOUND AS MEDIUM [INPUT GRAVI-TONES]' to the 'SONIC SADDLE [SIGNIFIER]', (2) from the 'LISTENING EXPERIENCE' to the 'APPLICATION OF METAPHORS [SIGNIFIEDS]', and (3) in the 'APPLICATION OF METAPHORS [SIGNIFIEDS]'.
    1. can occur because of our unique ears and physical perception.
    2. is defined by each individual's evolving listening experience of the GS modules and long-term mental representations of: (1) inputs to the GSF module that are attributed with a single GS, and (2) patterns of multiple GS'.
    3. is defined by two experiential properties that were discussed in sections '3.20: Conceptual Metaphor' and '3.21: Universality', respectively:
        - the projection of GS container schemas onto physically instantiated container schemas.

- the embellishment of “Pitch Distance is Physical Distance” with other metaphors.

The analysis of Chapter 4 will apply GSF ‘objectively’ in accordance with its four qualities at the ‘neutral level’ (Nattiez, 1990, pp. 12). However, the three windows for a potential slippage of meaning should be remembered as caveats to GSF’s objectivity. The second window will be a regular feature of the analysis.



Example 3.23a: The full model of Gravitonicity, housing responses to all three research questions. In response to RQ1: Gravitonicity is our experiential application of METAPHOR 1 and METAPHOR 2, based on our embodied understanding of distance and motion in the MATERIAL WORLD. The core components of the 'neutral level' (Nattiez, 1990, pp. 12) model – developed in response to RQ2 – are outlined below each metaphor. Lastly, in response to RQ3, there are three windows for a potential SLIPPAGE of meaning that can lead to a subjective experience of Gravitonicity.

Chapter 4: Analysis

This Chapter will demonstrate and bring detail to both models of Gravitonicity through their analytical application to the chord-melody jazz guitar repertoire. This repertoire has been selected as the ‘case study’ for three reasons: (1) it offers a rich vocabulary of GS’ and detailed, frequently negotiable Gravi-Tone Series Filtering (GSF) (2) to address the general paucity of scholarly attention towards the jazz guitar; (3) and a personal resonance with the repertoire (largely driven by Gravitonicity), having studied and played much of it for an undergraduate dissertation, master’s recital, and personal interest.

Although the origins and definition of the term ‘chord-melody’ are unclear, it is generally understood to mean the harmonisation of a melody line with chords. However, the lack of a fixed definition has seemingly led many guitarists to interpret the term as being limited to homophonic harmonisation. For example, at the beginning of the video *Jazz Guitar Improvisation: “Chord-Melody Style”* (1986), Barney Kessel dismisses the term and relabels the style as ‘harmonic treatment, because when you say chord-melody, it sort of infers that you need a chord for every melody note’.

Similarly, across Martin Taylor’s various pedagogical resources, he consistently distinguishes chord-melody as merely the ‘entry point’ (Guitar, 2016) to a more ‘polyphonic’ approach in which ‘the melody, chords, and bass all operate independently’ (Taylor and Alexander, 2018, Introduction). However, ‘chord-melody’ will be used in this research because it remains the most common name for the repertoire. It will be defined as: when a guitarist plays a melodic line (composed or improvised) and uses homophonic and/or polyphonic textures to harmonise it in a solo or ensemble setting.

The analysis aims to outline the gravitonic (i.e., relating to Gravitonicity) evolution of the chord-melody jazz guitar by comparing early to more recent repertoire. Example 4a illustrates the selected repertoire for both eras and the transcriptions that will be analysed. Whilst many famous players have necessarily been omitted from each era (and the years between), the analysis will illustrate that the selection remains a detailed (albeit general) representation of changes in gravitonic conception.

Era	Guitarist, Piece, Year	Transcription
The 1930's and 40's	Dick McDonough: *Honeysuckle Rose* (1934)	Mairants, 2002a, pp. 52-55
	Django Reinhardt: *Echoes of Spain* (1939)	Rea, 2020
	Carmen Mastren: *Two Moods* (1945)	Mairants, 2002a, pp. 107-110
	George Van Eps: *Once in A While* (1949)	Leduc, 2019b
Virtuoso (Pass, 1973b) to Present	Joe Pass: *Have You Met Miss Jones?* (1973a)	Leone, 1998
	Allan Holdsworth: *Looking Glass* (1986)	Holdsworth, 1993
	Ben Monder: *O.K. Chorale* (1996)	Monder, 2008
	Pasquale Grasso: *Have You Met Miss Jones?* (TRENIER GUITARS, 2016)	Leduc, 2019a

Example 4a: The selected chord-melody jazz guitar repertoire (Guitarist, Piece, Year), the transcriptions that will be analysed, and two eras that each comprise four pieces.

In the interests of variety, the repertoire for the early chord-melody jazz guitar spans a fifteen-year period. McDonough, Mastren, and Van Eps' pieces each illustrate chord-melody playing with different kinds of accompaniment whereas Reinhardt's piece belongs to the gypsy jazz tradition. The period was also somewhat determined by the limited availability of recordings and transcriptions.

For the second era, the chosen starting point is the seminal release of Joe Pass' *Virtuoso* album in 1973. *Virtuoso* represents the beginning of Pass' solo career and is considered by many to be his greatest work. In *The History of Jazz* (2011), Ted Gioia states that the album 'attracted attention for the guitarist's speed of execution and astonishing technical mastery of the instrument. Inspiring comparisons with Art Tatum and Oscar Peterson' (pp. 346). Moreover, in the years following its release, Pass has been heralded by Herb Ellis (another famous jazz guitarist) as the player who 'invented the solo guitar' (Mairants, 2002b, pp. 5) and by the Los Angeles Times as 'certainly the king of solo jazz guitar' (Sutro, 2016).

The analysis will assess the extent to which Pass' accolades may be attributed to his gravitonic concept through comparison to earlier and later works. To carefully test this hypothesis, the later repertoire spans a half-century and is stylistically diverse. For example, whereas Pasquale Grasso may reductively be considered as continuing the Pass tradition of solo hollow-body guitar playing, Allan Holdsworth uses chord-melody playing in a fusion context. Ben Monder, on the other hand, might be considered to represent a more 'modern' breed of jazz guitarist with his quasi-classical technique, unconventional chord voicings, and use of effects pedals.

The analysis of each era will begin with a brief overview of the selected repertoire and their harmonic settings e.g., solo or w/ various types of accompaniments. These overviews will be followed by two main analytical sections.

Firstly, the 'GS Vocabulary' sections will present a table that represents the Gravi-Tone Series' (GS') attributed across the duration of the four pieces. Those represented will be the least-negotiable candidates for GSF to attribute, which will be discussed in the second main analytical section. This will be followed by a discussion of the GS vocabulary and the derivation of *g* values for any chromatically altered chord scale GS' (as demonstrated in section '3.11: Chromatically Altered Chord Scale GS''). There will be less new GS' to systematise for the second era as it shares many with the first.

Secondly, the ‘Gravi-Tone Series Filtering’ sections will analyse and discuss how the GS vocabulary of the given era is attributed by the four qualities of GSF. As a reminder, the four qualities are: (1) the present tone(s), (2) their harmonic spectra, (3) memory traces of preceding tones, and (4) the unified time dimension (Z axis). Each GS will receive individual attention that covers all pieces in which they may be attributed. As a result, despite regular cross-referencing, the analysis for each GS can be read and understood in any order. Both ‘Gravi-Tone Series Filtering’ sections will be concluded with short summaries of their core findings.

Except for symmetric diminished, GS’ based on diminished seventh chords will be omitted from the analysis. This is primarily due to the seemingly extensive number of them. Section ‘A.6: Diminished Seventh Chords’ in the Appendix illustrates that the symmetric diminished GS is reserved for diminished seventh chords that are not functioning diatonically. In the context of a key, however, the appropriate GS is contingent on the root of the chord and whether it is ascending, descending, or an auxiliary of another chord.

Although eight diminished seventh chord scales are shown in the Appendix that may be developed into GS’, it seems reasonable that many more are possible when accounting for the functional relationships of modality, blues, ‘nonfunctional relationships’ (Nettles and Graf, 1997, pp. 162), and ‘the new modalism’ (Vieru, 1993, pp. 16). The potential number of these GS’ (coupled with their specificity of application) means that the selected chord-melody jazz guitar repertoire does not bring sufficient evidence to trace an evolution. Additionally, diminished seventh chord GS’ in the repertoire are consistently limited to the Chord Tones (CT’s) with the occasional use of a single Tension (T).

For each piece, the findings of the two analytical sections should not be considered to represent the entire gravitonic concept of each guitarist’s chord-melody playing. Because many of the pieces are arrangements, Gravitonicity is somewhat dictated and limited by the original composition. This must remain a consideration despite the tendency of jazz musicians to variably reharmonise a piece.

For example, although it will be evidenced how Pass' and Grasso's pieces offer individual gravitonic palettes, both draw their primary colours from *Have You Met Miss Jones?* (Rogers and Hart, 1937). It should also be considered that the expressed GS vocabulary of each guitarist may be constrained by the general aesthetic of each piece and/or specific functional relationships. Therefore, intra-era comparisons will be handled with a light touch rather than a sense of competition.

Section '4.7: Results' will summarise the findings of all analytical sections and how Gravitonicity has evolved from the first era to the second. This will also contextualise the significance of Joe Pass' gravitonic concept. Pass will be the only exception to the general avoidance of competition between the guitarists as his performance of *Have You Met Miss Jones?* (1973a) exhibits a considerable degree of freedom with reharmonisation. Nevertheless, it should be remembered that a single piece is unlikely to represent his entire gravitonic concept. The future of the chord-melody jazz guitar will also be hypothesised through the potentials of Gravitonicity that the players have yet to approach or fulfil.

4.1: The 1930's and 40's

The selected repertoire for the 1930's and 40's includes: Dick McDonough's solo arrangement of *Honeysuckle Rose* (1934); Django Reinhardt's solo performance of *Echoes of Spain* (1939), an original composition; Carmen Mastren's *Two Moods* (1945), an original composition with orchestral accompaniment; and George Van Eps' arrangement of *Once in A While* (1949), accompanied by bass and drums.

4.2: GS Vocabulary

Example 4.2a shows the GS' that GSF may attribute across the duration of each piece. The GS' in McDonough, Mastren, and Van Eps' pieces are generally used to construct tonal relationships. Whilst the GS' that correspond to the modes of the major scale are generally well-represented in these pieces, Phrygian only occurs in Van Eps', Mixolydian 7sus4 and Aeolian are absent from one piece each, and Locrian is absent from all three. Of these three pieces, only Van Eps' *Once in A While* (1949) uses the altered and melodic minor GS'. Lydian b7 is used in all four pieces.

		REPERTOIRE			
		Dick McDonough: *Honeysuckle Rose* (1934)	Django Reinhardt: *Echoes of Spain* (1939)	Carmen Mastren: *Two Moods* (1945)	George Van Eps: *Once in A While* (1949)
GRAVI-TONE SERIES'	Ionian	✓	✓	✓	✓
	Ionian maj7sus4		✓		
	Dorian	✓	✓	✓	✓
	Dorian AN-7	✓	✓		✓
	Phrygian		✓		✓
	Lydian	✓	✓		✓
	Mixolydian	✓	✓	✓	✓
	Mixolydian 7sus4	✓	✓		✓
	Aeolian		✓	✓	✓
	Locrian		✓		
	Lydian b7	✓	✓	✓	✓
	altered		✓		✓
	melodic minor		✓		✓
	harmonic minor		✓		
	whole-tone +7				
	whole-tone 7b5				
	symmetric dominant				
	symmetric diminished				
	chromatically altered chord scale GS'	Mixolydian (#9) Mixolydian (b9, #9)	Lydian (#9) Mixolydian (b13) Mixolydian (#9, b13) Mixolydian (b9, #9, b13) Lydian b7 (#9)	Mixolydian (b13) Mixolydian (b9, #9) Mixolydian (#9, b13)	Mixolydian (#9) Mixolydian (b13) Mixolydian (b9, #9) Mixolydian (#9, b13) Mixolydian (b9, #9, b13) Mixolydian 7sus4 (b13) Lydian b7 (#9) altered (♮9)

Example 4.2a: The GS' that GSF may attribute across the duration of the selected repertoire for 'The 1930's and 40's' era.

Reinhardt's *Echoes of Spain* (1939) is somewhat dissimilar to the other pieces because it uses GS' derived from modes of the harmonic minor scale to construct functional relationships: harmonic minor itself, Mixolydian (b9, #9, b13) (built off the fifth degree), and Lydian (#9) (built off the sixth degree). Like symmetric dominant and symmetric diminished, the Mixolydian (b9, #9, b13) scale contains eight gravi-tones, meaning the GS contains four UT's. Mixolydian (b9, #9, b13) adds the #9 gravi-tone – producing a -7 interval from the minor root – making it a composite mode of the harmonic and natural minor scales.

Although harmonic minor and Mixolydian (b9, #9, b13) are named in *The Chord Scale Theory & Jazz Harmony* (Nettles and Graf, 1997) (see the Appendix for their application), none of the harmonic minor-derived GS' are organised into Chord Tones (CT's), Tensions (T's), and Avoid Notes (AN's). This task and the derivation of *g* values is undertaken at the end of this section alongside the chromatically altered chord scale GS'.

Because harmonic minor is a well-known scale with a name that does not indicate chromatic alteration (despite the traditional understanding of the seventh being raised), it has been added to the main pool of GS' in Example 4.2a. In addition to the harmonic minor scale-derived GS', Reinhardt's piece demonstrates a rich vocabulary of GS' that is comparable to Van Eps' piece. Furthermore, *Echoes of Spain* (Reinhardt, 1939) includes two other 'main' GS': Ionian maj7sus4 and Dorian AN-7. The latter is also used in McDonough and Van Eps' pieces.

Like the relationship between Mixolydian and Mixolydian 7sus4, these GS' do not change the scale but the chord scale formulation (as discussed in section '3.14: GS Subsets and 'Exotic' Scales'). Both feature changes to the CT's: Ionian maj7sus4 replaces Ionian's scale degree 3 CT with sus4, and Dorian AN-7 positions Dorian's -7 CT as an AN. The Nettles and Graf text does not mention Ionian maj7sus4 but systematises Dorian AN-7 (1997, pp. 79). However, whereas they position Dorian AN-7's scale degree 6 as a CT, only 1, -3, and 5 will be treated as such here. This will be justified in the next section.

Because Ionian maj7sus4 and Dorian AN-7 do not require any chromatic alterations, they have been added alongside harmonic minor to the main pool of GS' in Example 4.2a. As with the harmonic minor scale-derived GS', the *g* values of these GS' are calculated at the end of this section alongside the chromatically altered chord scale GS'.

In addition to Mixolydian (b9, #9, b13) and Lydian (#9), the chromatically altered chord scale GS' shown in Example 4.2a include Lydian b7 (#9), Mixolydian 7sus4 (b13), five other versions of Mixolydian, and altered (♮9). Lydian b7 (#9) notably occurs in *Echoes of Spain* (Reinhardt, 1939) and *Once in A While* (Van Eps, 1949), the two pieces with the most diverse GS vocabulary. Whereas Mixolydian 7sus4 (b13) occurs in only one piece, the altered versions of Mixolydian (to which altered (♮9) may also be grouped) are common to all four.

The commonality and range of alterations to Mixolydian is due to its shared functionality with the altered GS to resolve up a perfect fourth (or down a perfect fifth) from primary and secondary dominant chords. CST lists the following chord scales (GS') for these chords (also shown in the Appendix). V7/I is the primary dominant (i.e., G7 in C major) and the remaining chords are secondary dominants e.g., in C major, V7/II would be A7 with the expected resolution of a D minor chord. Nettles and Graf are not specific as to whether whole-tone refers to the +7 or 7b5 version, so both might be assumed to be options.

V7/I: Mixolydian, Mixolydian with alterations, altered, whole-tone

V7/II: Mixolydian (b13), Mixolydian (b9, #9, b13), altered, whole-tone

V7/III: Mixolydian (b9, #9, b13), altered, whole-tone

V7/IV: Mixolydian, Mixolydian with alterations, altered, whole-tone

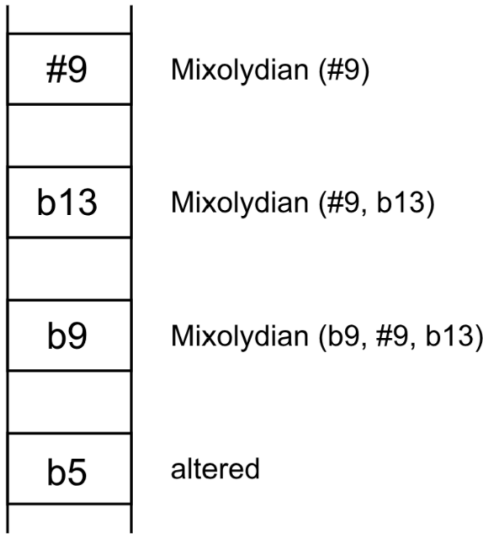
V7/V: Mixolydian, Mixolydian with alterations, altered, whole-tone

V7/VI: Mixolydian (b9, #9, b13), altered, whole-tone

For each chord, there is a most diatonically-appropriate / least-altered GS (e.g., Mixolydian for V7/I, V7/IV, and V7/V; Mixolydian (b13) for V7/II; and Mixolydian (b9, #9, b13) for V7/III and V7/VI) and a maximally-altered GS: the altered GS itself. Although whole-tone is listed for all chords, both the +7 and 7b5 versions are problematic (marked by their absence from Example 4.2a) and will receive greater attention later. Finally, for V7/I, V7/IV, and V7/V, CST offers 'Mixolydian with alterations' as a middle-ground between the most diatonically-appropriate GS and altered.

'Mixolydian with alterations' describes the use of up to three alterations available from b9, #9, b5, and b13, with the use of all four resulting in an altered GS. On the surface, the potential combinations of these alterations would seemingly result in a considerable number of chromatically altered Mixolydian GS' (13 not including the altered GS). However, whilst this number reflects a suite of scale options for the practitioner, the chromatically altered Mixolydian GS' governing our perceptual reality are generally fewer.

In the spirit of George Russell (1953, 2001), Example 4.2b expresses how these options may be reduced with an 'altered ladder of fifths'. If the only alteration to a Mixolydian scale is #9, then the resulting GS is simply Mixolydian (#9). However, if a Mixolydian scale has a single alteration from b13, b9, or b5, then the resulting GS will have multiple alterations. This is due to the second quality of GSF: the harmonic spectra of present tone(s).



Example 4.2b: The altered ladder of fifths.

As discovered in the spectral analysis sections of Chapter 3, the third partial in the harmonic series of each present tone produces a fifth interval with considerable presence. Therefore, when a b13 alteration is made to a Mixolydian scale (Ab in C Mixolydian), #9 (D#) can also be heard. In other words, b13 produces Mixolydian (#9, b13) instead of Mixolydian (b13). Similarly, if b9 (Db) is the single alteration, then b13 will be heard amongst the partials.

Furthermore, in addition to b9 and b13, *The Chord Scale Theory & Jazz Harmony* (Nettles and Graf, 1997) argues (albeit without explanation) that 'If b9 is available, #9 is also available' (pp. 43). This connection between b9 and #9 can be explained with the idea expressed by Russell's 'ladder of fifths' (2001, pp. 3), that harmonics of harmonics contribute to the GS. Whereas Russell's ladder connects the full chromatic scale (as discussed in section '2.2: The Harmonic Series and Distance'), the reduced number of rungs in the altered latter of fifths makes it practically conceivable that b9 brings b13, which in turn brings #9. Consequently, it seems likely that a single b9 alteration produces a Mixolydian (b9, #9, b13) GS. By extension, it is arguable that the full altered ladder of fifths can be initiated with b5 (Gb) through the fifth interval to b9. This would collect all four alterations and produce an altered GS.

It seems plausible that the altered ladder of fifths is learned – imprinted on the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) – through long-term mental representations of the alterations and their related GS'. Even if a listener may not appreciate the relationship between a lone b5 alteration and #9 when first experienced, it will be learned through repeat exposure to this context, the relationships from and between the intermediary rungs of the ladder (b9 and b13), and the various combinations of alterations.

It is unlikely that this knowledge is shared by all listeners, particularly those who are lacking in experience of tonality. However, the altered ladder of fifths will be used throughout the analysis for two reasons: (1) although typically regarded as a feature of jazz, chromatically altered Mixolydian GS' are a varyingly common feature of Western harmony in general; and (2) the simple and consistent logic that binds the altered ladder of fifths suggests that it could be quickly assimilated with the appropriate listening experience.

Whilst Example 4.2a shows that the chromatically altered Mixolydian GS' directed by the ladder are the most common, it also shows that others are possible. These occur when unaltered Tensions negate those offered by the ladder or the diatonic context. For example, the ladder shows that a b13 alteration would also bring #9, producing a Mixolydian (#9, b13) GS. However, if b13 is accompanied by an unaltered 9, then the GS would be Mixolydian (b13) – as listed in the vocabulary of Mastren and Van Eps' pieces. Likewise, although

Mixolydian (b9, #9, b13) is the most diatonically-appropriate option for V7/III, the b13 may be negated by its unaltered equivalent. This would result in the Mixolydian (b9, #9) GS – as listed in the vocabulary of McDonough, Mastren, and Van Eps' pieces.

For the chromatically altered Mixolydian GS' containing b13, Nettles and Graf (1997) identify a potential problem:

> b13 sounds like an augmented 5th. If both it and natural 5 are harmonically used, the listener will be confused as to the position of 5. Both are available, but not together; one is *conditional* to the use of the other. (pp. 43)

However, in contexts where b13 is a present tone and ♮5 is absent (the norm for these GS'), there are three reasons why it is unlikely that the former replaces the latter as +5 / a CT. Firstly, the ♮5 has strong presence as the third partial of the fundamental. Secondly, as discussed in section '3.5: Upper Tensions', T's are *generally* placed above CT's in a chord voicing. Therefore, although b13 as a present tone may have marginally stronger presence than ♮5 as a partial, the tendency for a lower registral position of the latter increases its potential as a CT.

Thirdly, GSF's third quality (memory traces of preceding tones) almost always plays a significant role in the attribution of Mixolydian GS' in general e.g., dominant chords require preceding context to require resolution. Consequently, ♮5 will be regularly implicated in voice leading from preceding chords even if it is only present as a partial. So, if b13 does not replace ♮5 as +5, then why is it that 'Both are available, but not together' (Nettles and Graf, 1997, pp. 43)?

The b13 may be considered an AN in the company of ♮5. Although GS' with dominant seventh CT's do not usually contain AN's 'because of their inherent instability' (pp. 26) (except for AN11), b13 fulfils the criteria of being '*a half step above* a chord tone' (pp. 26) and causing a friction in GSF's processing – as discussed in section '3.5: Upper Tensions'.

Nevertheless, because b13 functions as a T when ♮5 is absent, it seems that there are two forms of every chromatically altered Mixolydian GS that contains b13: a version that preserves 5 as a CT but relegates b13 to an AN; and a version that preserves b13 as a T but relegates 5 to being either a special circumstance AN or UT. Whilst this duality may represent the perceptual 'reality' of these GS', the fact that only two gravi-tones are affected (which are very rarely present simultaneously) makes it an impractical solution. Therefore, in the analyses of this Chapter, all chromatically altered Mixolydian GS' that contain b13 will regard 5 as a CT and b13 as a T.

Finally, like the two versions of whole-tone, the problematic nature of symmetric dominant and symmetric diminished is marked by their absence from the vocabulary in this era. Both will receive attention later. The following spectral analysis will address the *g* values of Ionian maj7sus4, harmonic minor, Lydian (#9), five altered versions of Mixolydian, Mixolydian 7sus4 (b13), and Lydian b7 (#9). All will be represented in table format and as radar charts. The approach will be the same as in section '3.10: Spectral Analysis: *g* values'. As noted earlier, any shared *g* values may represent either a 'true' measure of distance or demonstrate the limits of the spectral analysis.

***Ionian maj7sus4*:**

CT configurations analysed: C3, C3+F3, C3+G3, C3+B3, C3+F3+G3.

- **CT (1, sus4, 5, maj7):** Akin to Mixolydian 7sus4, the *g* values of Ionian maj7sus4's CT's are difficult to distinguish. This is not helped by the lack of spectral data for the maj7sus4 chord. In the analysis of the equivalent Mixolydian 7sus4 CT configurations, it was found that F (sus4) and G (5) had equivalent presence. In the spectra of C3+B3, however, whereas G occurs twice with strong presence (SP) and once with medium presence (MP), F is absent. This is likely because F is cancelled out by F#, the third harmonic of B. Although F is a present tone (PT) in the maj7sus4 chord, it may be hypothesised that its presence is similarly suppressed by B's third harmonic. This much cannot be proven without the data, however. Consequently, sus4, 5, and maj7 be judged to jointly occupy *g*2-*g*4. All will be represented as *g*2. Nettles and Graf (1997) would perhaps categorise maj7 as an AN due to the tritone interval – 'the basis for dominant sound and function' (pp. 27) – it forms with sus4. However, as discussed in section '3.4: The Chord Scale Theory', tritones may not be an appropriate way of deriving AN's. Although the dissonance brought by maj7 suggests that it may be less used in Ionian maj7sus4 contexts, it is a characteristic of the GS and does not bring a notable challenge to GSF.
- **T (T9, T3, T13):** The presences of D (T9) and E (T3) are competitively matched in the spectra of C3, C3+F3, and C3+B3. However, of the two, only D is present in the spectra of C3+G3 and the sus4 triad. This suggests that E's presence would be similarly lacking in the spectra of the maj7sus4 chord. Consequently, T9 may be judged to be closer than T3.

  A (T13) occurs with weak presence (WP) (and no presence (NP) after 1000ms) in the spectra of C3, WP in the spectra of C3+B3, a strong MP in the spectra of the sus4 triad, and SP in the spectra of C3+F3. In the latter two, A gains presence as the fifth harmonic of the F PT. This suggests that it would likewise have significant presence in the spectra of the maj7sus4 chord, making it closer than T3. Although A has stronger presence than D in the spectra of C3+F3, D is stronger in the spectra of all other CT configurations. Notably, D's victory in the spectra of the sus4 triad suggests similar for the maj7sus4 chord. As a result, T9, T13, and T3 may respectively be attributed with *g*5, *g*6, and *g*7.

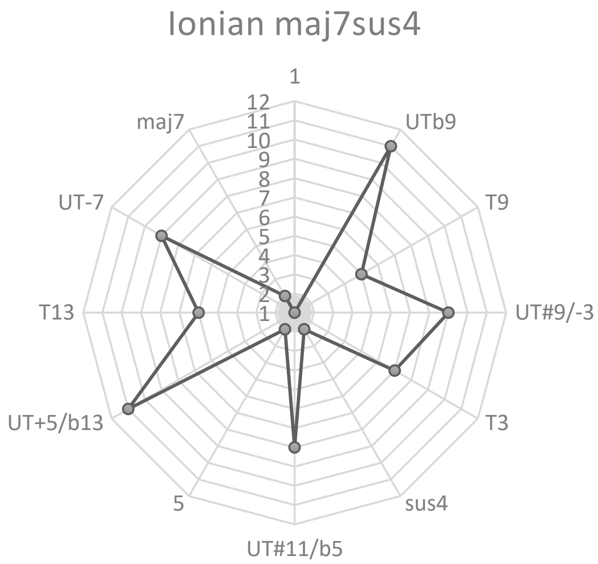
- **UT (UTb9, UT#9/-3, UT#11/b5, UT+5/b13, UT-7):** Bb (UT-7) is the most well-represented of the UT's, occurring with a MP in the spectra of all CT configurations. Although absent from most CT configurations, D#/Eb (UT#9/-3) is 5dB louder than Bb in the spectra of the sus4 chord and they are competitively matched in the spectra of C3+B3. The former compensates for D#/Eb's absence in the spectra of other CT configurations whereas the latter suggests a similar story for the maj7sus4 chord. These UT's may be recognised as equidistant.

  Whilst F#/Gb (UT#11/b5) occurs with WP in the spectra of C3 and C3+F3, and NP in the spectra of the sus4 triad, it gains a victory over Bb and D#/Eb in the spectra of C3+B3 with a SP. The SP is derived from F#/Gb being the third harmonic of the B PT, suggesting a similar victory for F#/Gb in the spectra of the maj7sus4 chord. Consequently, UT#11/b5 may be regarded as closer than the equidistant UT-7 and UT#9/-3.

  Db (UTb9) and G#/Ab (UT+5/b13) have comparatively weak representation across the spectra of the CT configurations. Of the two, G#/Ab has the strongest occurrence as a WP (and NP after 1000ms) in the spectra of C3. This suggests that it would be optimistic to try and separate their *g* values. As a result, UT#11/b5 may be attributed with *g*8, UT#9/-3 and UT-7 jointly occupy *g*9-*g*10 (both represented as *g*9), and UTb9 and UT+5/b13 jointly occupy *g*11-*g*12 (both represented as *g*11).

*g*1	*g*2			*g*5	*g*6	*g*7	*g*8	*g*9		*g*11	
1	sus4	5	maj7	T9	T13	T3	UT#11/b5	UT#9/-3	UT-7	UTb9	UT+5/b13

Example 4.2c: Ionian maj7sus4 *g* values (table).



Example 4.2c cont.: Ionian maj7sus4 *g* values (radar chart).

***Dorian AN-7*:**

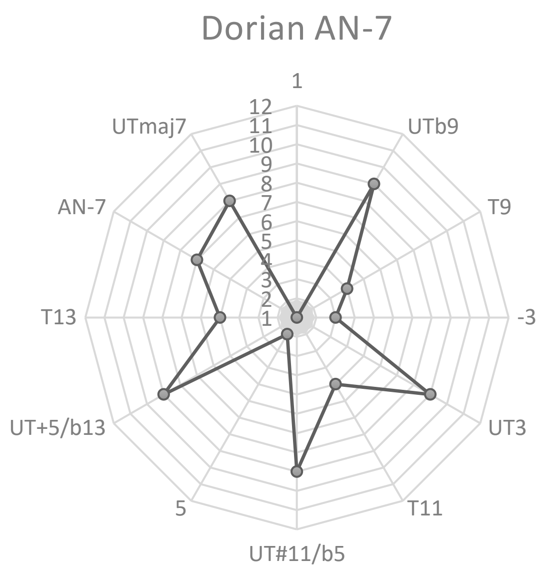
CT configurations analysed: C3, C3+Eb3, C3+G3, C3+Eb3+G3.

- **CT (1, -3, 5):** The same as Dorian without -7 or accounting for the spectra of the C3+Bb3 and minor seventh chord CT configurations. Like Dorian, G's greater presence than Eb across the spectra of the CT configurations means 5 and -3 can be respectively attributed with *g*2 and *g*3.
- **T (T9, T11, T13):** Unlike the CT's, not accounting for the spectra of C3+Bb3 and the minor seventh chord changes the *g* values of Dorian's T's. This is because F (T11) – which is equidistant with D (T9) in Dorian – only occurs with MP in the spectra of C3+Eb3, giving it proximal presence to A (T13). As a result, T9 is the closest (*g*4) whereas T11 and T13 may be judged to jointly occupy *g*5-*g*6 (both will be represented as *g*5).
- **AN (AN-7)**: As the lone AN, AN-7 may be attributed with *g*7. Nevertheless, it stills occurs with SP in the spectra of C3+Eb3 and the minor triad, and MP and WP in the spectra of C3. This suggests that it offers little disturbance to the GS. Unlike any other GS covered by this research, this AN is not derived from the '*half step above* a chord tone' (pp. 26) rule but its relationship with T13. This will be explained in the next section.
- **UT (UTb9, UT3, UT#11/b5, UT+5/b13, UTmaj7):** Like the T's, the reduced number of CT configurations changes the *g* values of Dorian's UT's. B (UTmaj7) is the only UT that has consistently strong representation across the spectra, occurring with MP in the spectra of C3+Eb3, C3+G3, and the minor triad, and WP in the spectra of C3. Whilst Db (UTb9) and E (UT3) also achieve 'victories' in the spectra of C3 and C3+Eb3, they occur as weak NP's in the spectra of the minor triad – now the main CT configuration. As a result, UTmaj7 be attributed with *g*8 and all the remaining

UT's with *g*9-*g*12 (all will be represented as *g*9). The only difference to Dorian is that UTb9 not equidistant with UTmaj7 as the closest UT's.

*g*1	*g*2	*g*3	*g*4	*g*5		*g*7	*g*8	*g*9			
1	5	-3	T9	T11	T13	AN-7	UTmaj7	UTb9	UT3	UT#11/b5	UT+5/b13

Example 4.2d: Dorian AN-7 *g* values (table).



Example 4.2d cont.: Dorian AN-7 *g* values (radar chart).

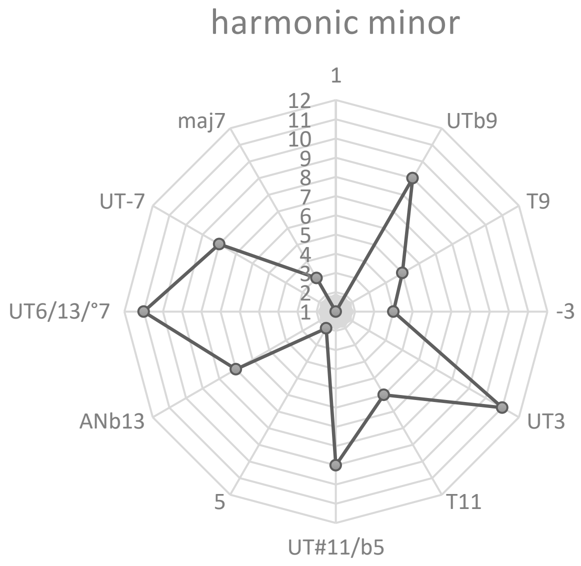
***harmonic minor*:**

CT configurations analysed: C3, C3+Eb3, C3+G3, C3+B3, C3+Eb3+G3, C3+Eb3+G3+B3.

- **CT (1, -3, 5, maj7):** The same as melodic minor.
- **T (T9, T11):** The same as melodic minor without T13: T9 is *g*5 and T11 is *g*6.
- **AN (ANb13):** Ab (ANb13) only has WP (and NP after 1000ms) in the spectra of C3, justifying the AN status. This extremely weak representation is only matched in the GS' analysed so-far by Ionian's AN11, which does not occur in the spectra of any CT configuration. Therefore, harmonic minor's ANb13 may offer a comparably strong challenge to GSF. As the lone AN, ANb13 can be attributed with *g*7.
- **UT (UTb9, UT3, UT#11/b5, UT6/13/°7, UT-7):** UT6/13/°7 (A) replaces UT+5/b13 (G#/Ab) of melodic minor. For melodic minor, UT3 and UT+5/b13 were judged to jointly occupy the space of *g*11-*g*12, with both being represented as *g*11. UT3 only occurs with a weak MP in the spectra of C3+B3, a WP in the spectra of C3, and NP in the spectra of the minor triad. UT6/13/°7 has similarly weak presence. It occurs with weak MP in the spectra of C3+Eb3, and WP in the spectra of C3 (and NP after 1000ms) and C3+B3. Therefore, akin to UT+5/b13 in melodic minor, UT6/13/°7 can be judged to jointly occupy *g*11-*g*12 with UT3.

*g*1	*g*2	*g*3	*g*4	*g*5	*g*6	*g*7	*g*8	*g*9		*g*11	
1	5	maj7	-3	T9	T11	ANb13	UT-7	UTb9	UT#11/b5	UT3	UT6/13/°7

Example 4.2e: harmonic minor *g* values (table).



Example 4.2e cont.: harmonic minor *g* values (radar chart).

***Lydian (#9)*:**

CT configurations analysed: C3, C3+E3, C3+G3, C3+B3, C3+E3+G3, C3+E3+G3+B3.

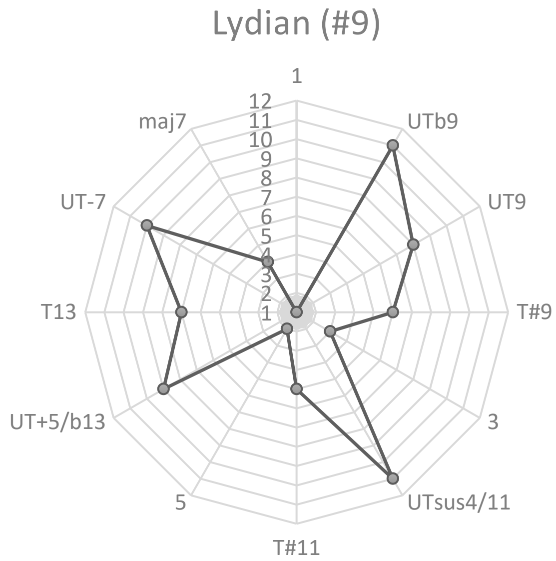
- **CT (1, 3, 5, maj7):** The same as Lydian.
- **T (T#9, T#11, T13):** The analysis for Lydian demonstrated that F# (T#11) is closer than A (T13). D# (T#9), the replacement to Lydian's D (T9), occurs with MP in the spectra of C3+B3 and the major seventh chord, WP in the spectra of the single tone, and NP in the spectra of the single tone and the major triad. This gives D# a stronger presence across the CT configurations than A, because the latter only occurs with WP in the spectra of C3 (and NP after 1000ms), C3+E3, and C3+B3. Contrastingly, F# may be judged to be closer than D# due to the former's SP in the spectra of C3+B3, a stronger MP than D#'s in the spectra of the major seventh

chord, and a WP in the spectra of C3. Therefore, T#11, T#9, and T13 may be respectively attributed with *g*5, *g*6, and *g*7.

- **UT (UTb9, UT9, UTsus4/11, UT+5/b13, UT-7):** Other than UT9 (D) replacing UT#9/-3 (D#/Eb), the distance order of the Lydian (#9) UT's is the same as Lydian's. D has a stronger presence than G#/Ab (UT+5/b13), the closest of Lydian's UT's. Whereas G#/Ab occurs with MP in the spectra of the major triad and major seventh chord, D has a SP in both. Consequently, UT9 and UT+5/b13 may be attributed with *g*8 and *g*9, respectively. This drops UT-7 from *g*9 in Lydian to *g*10 in Lydian (#9). Like Lydian, UTb9 and UTsus4/11 jointly occupy *g*11-*g*12, with both being represented as *g*11.

*g*1	*g*2	*g*3	*g*4	*g*5	*g*6	*g*7	*g*8	*g*9	*g*10	*g*11	
1	5	3	maj7	T#11	T#9	T13	UT9	UT+5/b13	UT-7	UTb9	UTsus4/11

Example 4.2f: Lydian (#9) *g* values (table).



Example 4.2f cont.: Lydian (#9) *g* values (radar chart).

***Mixolydian 7sus4 (b13)*:**

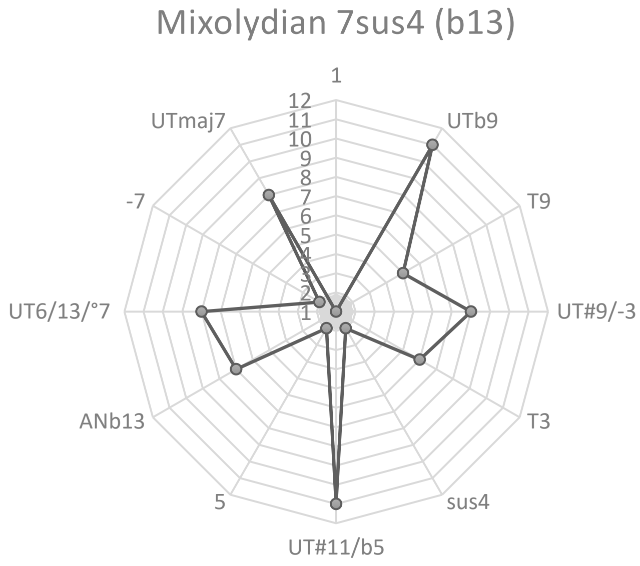
CT configurations analysed: C3, C3+F3, C3+G3, C3+Bb3, C3+F3+G3, C3+F3+G3+Bb3.

- **CT (1, sus4, 5, -7):** The same as Mixolydian 7sus4.
- **T (T9, T3):** The same as Mixolydian 7sus4 without T13.
- **AN (ANb13):** b13 is an usual chromatic alteration because, being a half step above scale degree 5, it is an AN. As the lone AN, ANb13 (Ab) may be attributed with *g*7. Because it only occurs with a WP in the spectra of C3 (and NP after 1000ms), and particularly weak NP in the spectra of the sus4 triad, it may also be concluded that ANb13 offers a significant challenge to GSF's processing.

  UT (UTb9, UT#9/-3, UT#11/b5, UT6/13/°7, UTmaj7): UT6/13/°7 (A) replaces UT+5/b13 (G#/Ab) of the unaltered version. In Mixolydian 7sus4, UT+5/b13 jointly occupies *g*10-*g*12 alongside UTb9 and UT#11/b5. However, UT6/13/°7 has presence that rivals UT#9/-3 and UTmaj7 – the joint closest UT's of Mixolydian 7sus4. UT6/13/°7 occurs with weak SP in the spectra of C3+F3, strong MP in the spectra of the sus4 triad and 7sus4 chord, and WP (and NP after 1000ms) in the spectra of C3. Due to the individual merits of UT#9/-3 and UTmaj7 (see Mixolydian 7sus4 analysis), UT6/13/°7 may be judged to be equidistant. Therefore, these three gravi-tones jointly occupy *g*8-*g*10 and will be represented as *g*8. Finally, as with Mixolydian 7sus4, UTb9 and UT#11/b5 are equidistant. Both occupy the space of *g*11-*g*12 and will be represented as *g*11.

*g*1	*g*2			*g*5	*g*6	*g*7	*g*8			*g*11	
1	sus4	5	-7	T9	T3	ANb13	UT#9/-3	UT6/13/°7	UTmaj7	UTb9	UT#11/b5

Example 4.2g: Mixolydian 7sus4 (b13) *g* values (table).



Example 4.2g cont.: Mixolydian 7sus4 (b13) *g* values (radar chart).

***Mixolydian (#9)*:**

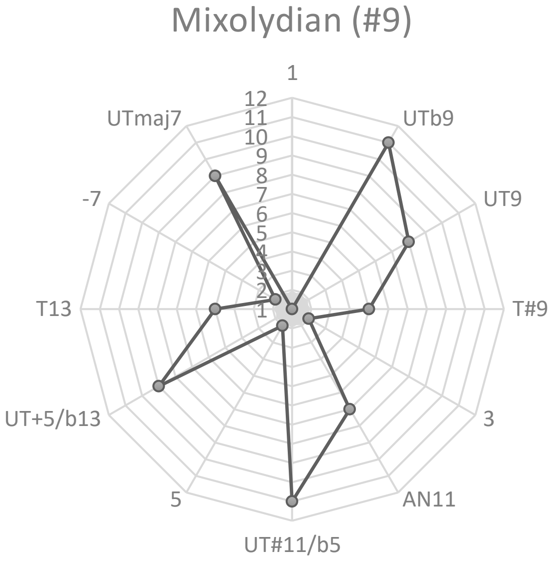
CT configurations analysed: C3, C3+E3, C3+G3, C3+Bb3, C3+E3+G3, C3+E3+G3+Bb3.

- **CT (1, 3, 5, -7):** The same as Mixolydian.
- **T (T#9, T13):** T#9 (D#) replaces T9 (D) of Mixolydian. The spectral analysis for Mixolydian illustrated that T13 (A) had minimal presence in the spectra of the CT configurations, only occurring with WP in the spectra of C3 (and NP after 1000ms) and C3+E3. The presence of D# is comparably weak, occurring with WP in the spectra of C3+E3, and NP in the spectra of C3 and the major triad. Therefore, T#9 and T13 may be judged to be jointly occupy *g*5-*g*6. Both will be represented as *g*5.
- **AN (AN11):** The same as Mixolydian.

- **UT (UTb9, UT9, UT#11/b5, UT+5/b13, UTmaj7):** UT9 (D) replaces UT#9/-3 (D#/Eb) of the unaltered version. D had the strongest presence of the T's in Mixolydian. In Mixolydian (#9), D has the strongest presence of the UT's in every CT configuration. UT9, therefore, may be attributed with *g*8. Factoring in T9 'jumping the queue', the distance order of the remaining UT's is identical to Mixolydian. UT+5/b13 and UTmaj7 are relegated by one *g* value to jointly occupy *g*9-*g*10, both represented as *g*9. Finally, UTb9 and UT#11/b5 are likewise relegated by one *g* value. They jointly occupy *g*11-*g*12 and both will be represented as *g*11.

*g*1	*g*2			*g*5		*g*7	*g*8	*g*9		*g*11	
1	3	5	-7	T#9	T13	AN11	UT9	UT+5/b13	UTmaj7	UTb9	UT#11/b5

Example 4.2h: Mixolydian (#9) *g* values (table).



Example 4.2h cont.: Mixolydian (#9) *g* values (radar chart).

Mixolydian (b13):

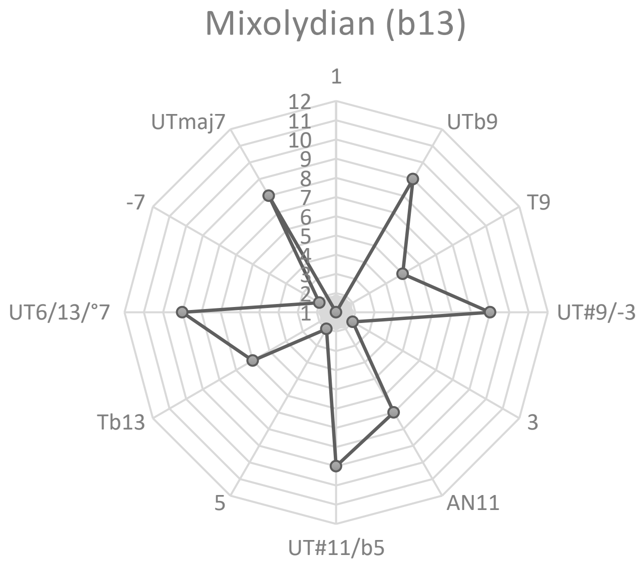
CT configurations analysed: C3, C3+E3, C3+G3, C3+Bb3, C3+E3+G3, C3+E3+G3+Bb3.

- **CT (1, 3, 5, -7):** The same as Mixolydian.
- **T (T9, Tb13):** The analysis for Mixolydian showed that D (T9) has considerable presence across the spectra of the CT configurations. Although Ab (Tb13) occurs as with SP in the spectra of C3+E3 (whereas D is absent), D has stronger presence in the spectra of all other CT configurations. In the spectra of the major triad and dominant seventh chord, for example, D has SP and Ab has MP. It may be concluded that T9 is *g*5 and Tb13 is *g*6.
- **AN (AN11):** The same as Mixolydian.

- **UT (UTb9, UT#9/-3, UT#11/b5, UT6/13/°7, UTmaj7):** UT6/13/°7 (A) replaces UT+5/b13 (G#/Ab) of the unaltered version. The analysis of the Mixolydian T's illustrated that A is scarcely present across the spectra of the CT configurations. In the UT's of Mixolydian (b13), this means that UT6/13/°7 joins UTb9, UT#9/-3, and UT#11/b5 as the most distant gravi-tones in the GS. These jointly occupy *g*9-*g*12 and will all be represented as *g*9. As in Mixolydian, the greater presence of UTmaj7 grants it *g*8.

*g*1	*g*2			*g*5	*g*6	*g*7	*g*8	*g*9			
1	3	5	-7	T9	Tb13	AN11	UTmaj7	UTb9	UT#9/-3	UT#11/b5	UT6/13/°7

Example 4.2i: Mixolydian (b13) *g* values (table).



Example 4.2i cont.: Mixolydian (b13) *g* values (radar chart).

***Mixolydian (b9, #9)*:**

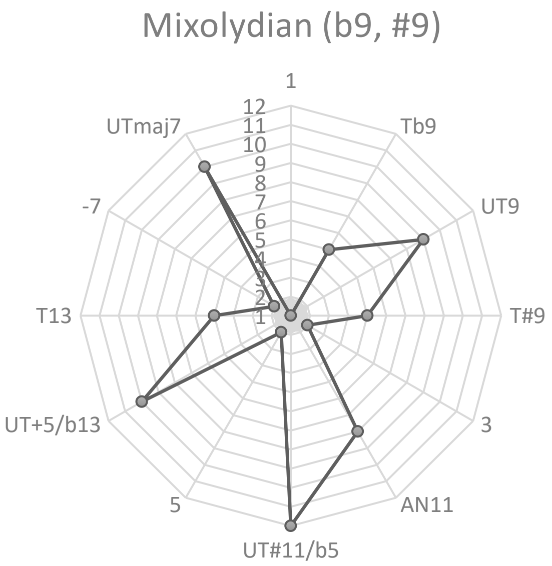
CT configurations analysed: C3, C3+E3, C3+G3, C3+Bb3, C3+E3+G3, C3+E3+G3+Bb3.

- **CT (1, 3, 5, -7):** The same as Mixolydian.
- **T (Tb9, T#9, T13):** The analysis of Mixolydian (b13)'s UT's illustrated that Db (UTb9), D#/Eb (UT#9/-3), and A (UT6/13/°7) are equidistant. Consequently, Tb9, T#9, and T13 may be judged to jointly occupy *g*5-*g*7. All will be represented as *g*5.
- **AN (AN11):** The same as Mixolydian except AN11 is relegated to *g*8 because of the extra Tension.
- **UT (UT9, UT#11/b5, UT+5/b13, UTmaj7):** Without UTb9 (Db), these UT's are shared with Mixolydian (#9). Therefore, UT9 (D) is the closest (*g*9), then the equidistant

UT+5/b13 (G#/Ab) and UTmaj7 (B) (*g*10-*g*11 – both represented as *g*10), and UT#11/b5 (F#/Gb) is the most distant (*g*12).

*g*1	*g*2			*g*5			*g*8	*g*9	*g*10		*g*12
1	3	5	-7	Tb9	T#9	T13	AN11	UT9	UT+5/b13	UTmaj7	UT#11/b5

Example 4.2j: Mixolydian (b9, #9) *g* values (table).



Example 4.2j cont.: Mixolydian (b9, #9) *g* values (radar chart).

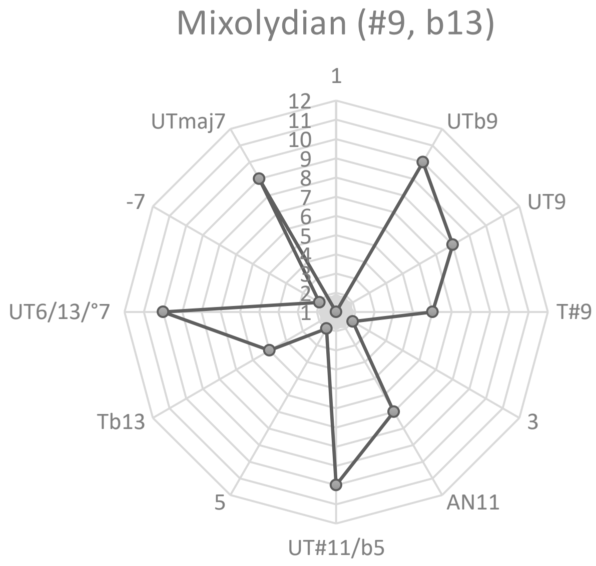
***Mixolydian (#9, b13)*:**

CT configurations analysed: C3, C3+E3, C3+G3, C3+Bb3, C3+E3+G3, C3+E3+G3+Bb3.

- **CT (1, 3, 5, -7):** The same as Mixolydian.
- **T (T#9, Tb13):** Neither of these T's are shared with Mixolydian. However, their relative presence has already been analysed as UT#9/-3 and UT+5/b13 of Mixolydian. Because the analysis showed that UT+5/b13 was closer than UT#9/-3, Mixolydian (#9)'s Tb13 (Ab) and T#9 (D#) can be attributed with *g*5 and *g*6, respectively.
- **AN (AN11):** The same as Mixolydian.
- **UT (UTb9, UT9, UT#11/b5, UT6/13/°7, UTmaj7):** The same as Mixolydian (#9) except UT+5/b13 (G#/Ab) is replaced by UT6/13/°7 (A). For Mixolydian (#9, b13), the analysis of Mixolydian (b13)'s UT's illustrated that UT6/13/°7 should be equidistant with UTb9 (Db) and UT#11/b5 (F#/Gb) as the most distant gravi-tones. These jointly occupy *g*10-*g*12 and will be represented as *g*10. Lastly, the analyses of the UT's in Mixolydian (#9) and Mixolydian (b9, #9) both illustrate that UT9 (D) is closer than UTmaj7 (B). Therefore, for Mixolydian (#9, b13), UT9 and UTmaj7 may be attributed with *g*8 and *g*9, respectively.

*g*1	*g*2			*g*5	*g*6	*g*7	*g*8	*g*9	*g*10		
1	3	5	-7	Tb13	T#9	AN11	UT9	UTmaj7	UTb9	UT#11/b5	UT6/13/°7

Example 4.2k: Mixolydian (#9, b13) *g* values (table).



Example 4.2k cont.: Mixolydian (#9, b13) *g* values (radar chart).

***Mixolydian (b9, #9, b13)*:**

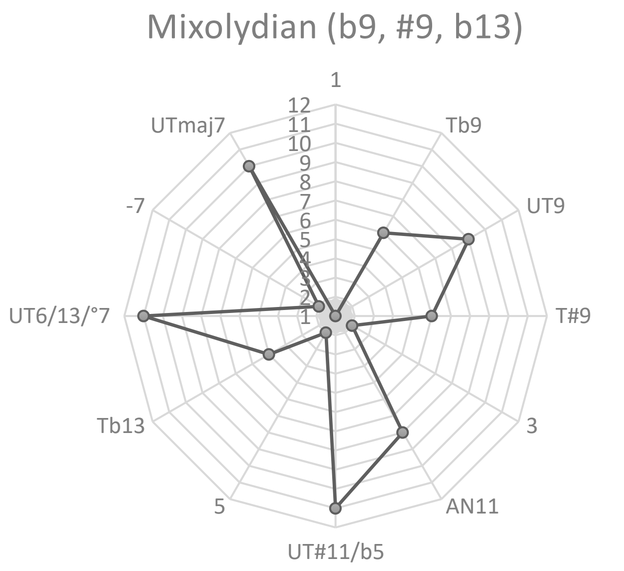
CT configurations analysed: C3, C3+E3, C3+G3, C3+Bb3, C3+E3+G3, C3+E3+G3+Bb3.

- **CT (1, 3, 5, -7):** The same as Mixolydian.
- **T (Tb9, T#9, Tb13):** Akin to Mixolydian (#9) and Mixolydian (#9, b13), none of Mixolydian (b9, #9, b13)'s T's are shared with Mixolydian. However, their relative presence has already been analysed as Mixolydian UT's. The analysis showed that UT+5/b13 was closer than both UTb9 and UTb13, which were judged to be equidistant. Therefore, in Mixolydian (b9, #9, b13), Tb13 may be attributed with *g*5, and Tb9 and T#9 can be considered to jointly occupy *g*6-*g*7 – both will be represented as *g*6. Interestingly, this distance order is shared with the altered GS.

- **AN (AN11):** The same as Mixolydian except AN11 is dropped to *g*8 because of the extra T.
- **UT (UT9, UT#11/b5, UT6/13/°7, UTmaj7):** All these UT's are shared with Mixolydian (#9, b13), which also includes UTb9. For Mixolydian (b9, #9, b13), the prior analysis shows that UT9 is the closest (*g*9), followed by UTmaj7 (*g*10), and that UT#11/b5 and UT6/13/°7 are jointly the most distant (*g*11-*g*12 – both represented as *g*11).

*g*1	*g*2			*g*5	*g*6		*g*8	*g*9	*g*10	*g*11	
1	3	5	-7	Tb13	Tb9	T#9	AN11	UT9	UTmaj7	UT#11/b5	UT6/13/°7

Example 4.2l: Mixolydian (b9, #9, b13) *g* values (table).



Example 4.2l cont.: Mixolydian (b9, #9, b13) *g* values (radar chart).

***Lydian b7 (#9)*:**

CT configurations analysed: C3, C3+E3, C3+G3, C3+Bb3, C3+E3+G3, C3+E3+G3+Bb3.

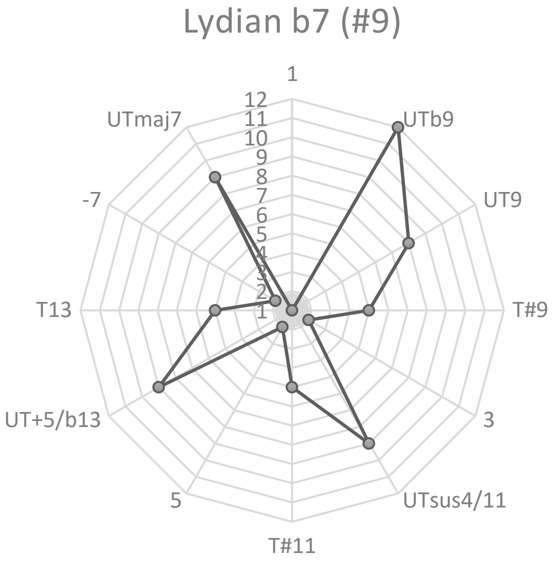
- **CT (1, 3, 5, -7):** The same as Lydian b7.
- **T (T#9, T#11, T13):** T#9 (D#) replaces T9 (D) of Lydian b7. The relative presence of these gravi-tones has already been analysed in the UT's section of Mixolydian (b13). It was found that their minimal presence resulted in equidistant *g* values. Consequently, it may be judged that T#9, T#11 (F#), and T13 (A) jointly occupy *g*5-*g*7. All will be represented as *g*5.
- **UT (UTb9, UT9, UTsus4/11, UT+5/b13, UTmaj7):** UT9 (D) replaces UT#9/-3 (D#/Eb) of Lydian b7. As the analyses of all GS' containing UT9 have illustrated, it has the strongest presence of the UT's. UT9 is also stronger than Lydian b7 (#9)'s

UTsus4/11 (F). Whereas the latter occurs with SP in the spectra of C3+Bb3 and the dominant seventh chord, UT9 occurs with SP in the spectra of all CT configurations except for a strong MP in the spectra of C3+Bb3.

Therefore, UT9 may be attributed with *g*8. The distance order of the remaining UT's is the same as Lydian b7, but all relegated by one *g* value to accommodate UT9. UTsus4/11, UT+5/b13, and UTmaj7 jointly occupy *g*9-*g*11 (all represented as g9), and UTb9 assumes *g*12.

*g*1	*g*2			*g*5			*g*8	*g*9			*g*12
1	3	5	-7	T#9	T#11	T13	UT9	UTsus4/11	UT+5/b13	UTmaj7	UTb9

Example 4.2m: Lydian b7 (#9) *g* values (table).



Example 4.2m cont.: Lydian b7 (#9) *g* values (radar chart).

***altered (♮9)*:**

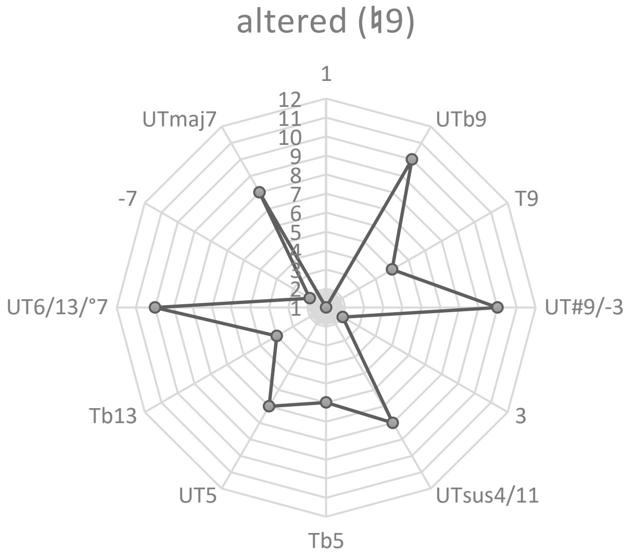
CT configurations analysed: C3, C3+E3, C3+Bb3, C3+E3+Bb3.

- **CT (1, 3, -7):** The same as altered.
- **T (T9, Tb5, Tb13):** Tb13 (Ab) was argued to be the closest of the altered T's. However, T9 (D) in altered (♮9) (replacing altered's Tb9 and T#9) brings a potential challenge to Tb13's crown. Whereas Ab occurs with SP in the spectra of C3+E3 and the 'altered triad', D occurs with noteworthy presence across the spectra of the CT configurations. Nevertheless, Ab's greater presence by 8dB in the spectra of the altered triad – the main CT configuration – suggests that it Is closer than D. In summary, Tb13, T9, and Tb5 may respectively be attributed with *g*4, *g*5, and *g*6.

- **UT (UTb9, UT#9, UTsus4/11, UT5, UT6/13/°7, UTmaj7):** The UTb9 (Db) and UT#9/-3 (D#/Eb) that replace altered's UT9 have equivalent presence to UT6/13/°7 (A), only notably occurring with WP in the spectra of C3+E3. Because UT6/13/°7 was the most distant of the altered UT's, it may be judged to jointly occupy *g*10-*g*12 with UTb9 and UT#9/-3 (all represented as *g*10). The analysis of the altered UT's also showed that UT5 (G) is the closest (*g*7 for this GS) whereas UTsus4/11 and UTmaj7 were 'runners-up' (jointly occupying *g*8-*g*9, both represented as *g*8).

*g*1	*g*2		*g*4	*g*5	*g*6	*g*7	*g*8		*g*10		
1	3	-7	Tb13	T9	Tb5	UT5	UTsus4/11	UTmaj7	UTb9	UT#9/-3	UT6/13/°7

Example 4.2n: altered (♮9) *g* values (table).

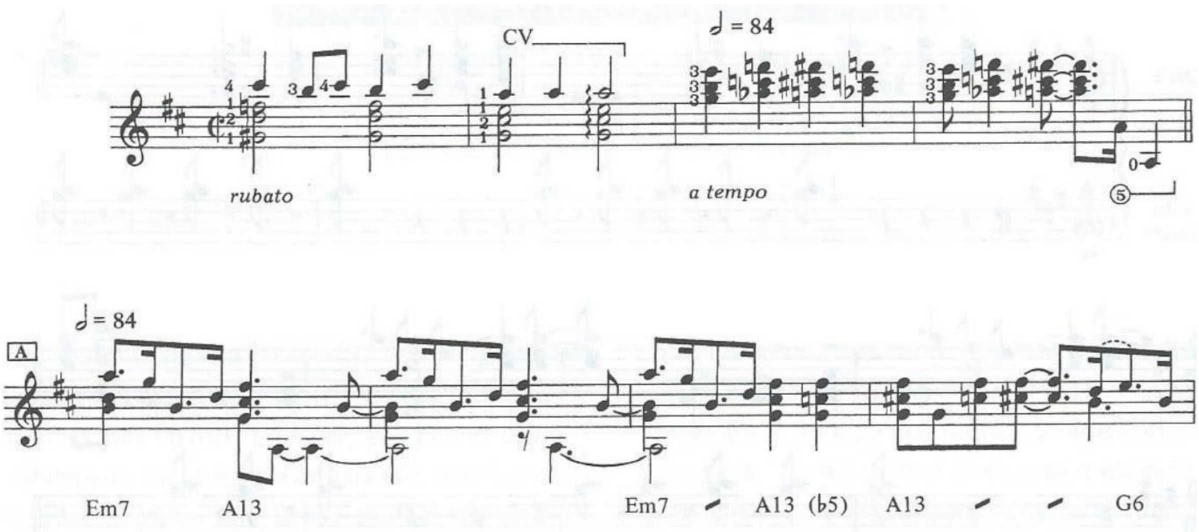


Example 4.2n cont.: altered (♮9) *g* values (radar chart).

<u>4.3: Gravi-Tone Series Filtering</u>

Ionian: Of the four pieces selected for this era, McDonough's most frequently creates negotiability for GSF through the lack of clearly defined fundamental tones / *g*1's. This may stem from McDonough's greater experience of playing with accompaniment, i.e., without the harmonic responsibility of supplying the fundamental bass. Example 4.3a demonstrates that this negotiability is evident from the outset of the piece.

Firstly, however, note that there are three errors in this excerpt of the transcription (Mairants, 2002a, pp. 52-55): the G# and F♮ of the first chord of bar one should be A and F#, respectively, changing to G# and F♮ in beat three; the C# in the first chord of bar two should be D, changing to C# on beat three; and the top line of bars three and four should be an F# pedal.

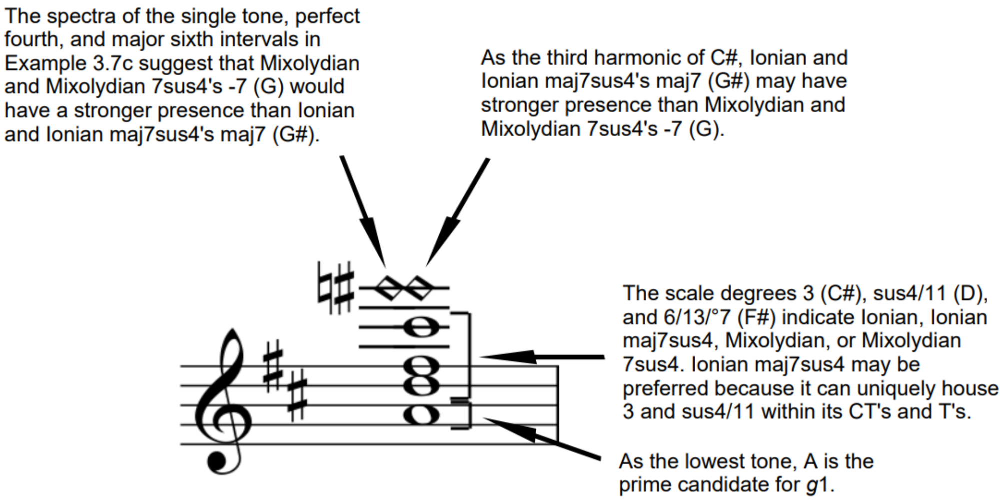


Example 4.3a: Bars 1-8 of McDonough's *Honeysuckle Rose* (1934), demonstrating negotiability through the lack of a clearly defined fundamental bass.

GSF is immediately challenged by the first chord (A-D-F#-C#). The lowest tone would suggest that A is *g*1. Relative to A, the other tones may lead GSF to attribute Ionian (C# = 3, F# = T13, D = AN11), Ionian maj7sus4 (D = sus4, C# = T3, F# = T13), Mixolydian (C# = 3, F# = T13, D = AN11), or Mixolydian 7sus4 (D = sus4, C# = T3, F# = T13). As the only GS capable of housing scale degrees 3 and sus4/11 as CT's and T's, Ionian maj7sus4 appears to be the most likely candidate.

The problem is further complicated by GSF's second quality, the harmonic spectra of present tones. Although the spectral content of this chord was not observed in section '3.10: Spectral Analysis *g* values', other PT (present tone) combinations illustrate the potential problems. The stronger presence of scale degree -7 than maj7 in the spectra of the single tone, C3+F3 (equivalent to A+D), and C3+A3 (equivalent to A+F#), suggests that Mixolydian and Mixolydian 7sus4 continue to be options for GSF.

Contrastingly, because the harmonic series of C# (scale degree 3) brings G# (maj7) with the considerable presence of the third harmonic, there is also a spectral argument for Ionian and Ionian maj7sus4. This 'neutral level' (Nattiez, 1990, pp. 12) analysis of the present tones and possible spectra of the first chord in McDonough's piece is laid out in Example 4.3a cont. The lack of preceding tones and polyrhythms means that GSF's third and fourth qualities are not factors.



Example 4.3a cont.: GSF's 'neutral level' (Nattiez, 1990, pp. 12) processing of the present tones and possible spectra of the first chord in McDonough's *Honeysuckle Rose* (1934). For ease of reading, the G# harmonic is written an octave lower than it sounds.

Furthermore, for listeners with experience of tonality, the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) may have been shaped to expect GS' corresponding to tonic chords at the beginning of a piece. Therefore, despite the disruptive presence of AN11, Ionian – as the GS corresponding to the tonic chord of a major key – may have the 'winning ticket'.

Because the preceding analysis has only dealt with the first beat of the first piece, it may seem needlessly detailed and distanced from practical sense. However, it only begins to illustrate the perceptual (and therefore analytical) difficulties incurred when a fundamental tone is not clearly defined. Other similar 'rabbit holes' can be uncovered by reconsidering the fundamental tone e.g., D as *g*1 = D6/A, F# as *g*1 = F#-(b13)/A, C# as *g*1 = an unusual interval structure (D = b9, F# = sus4/11, A = +5/b13).

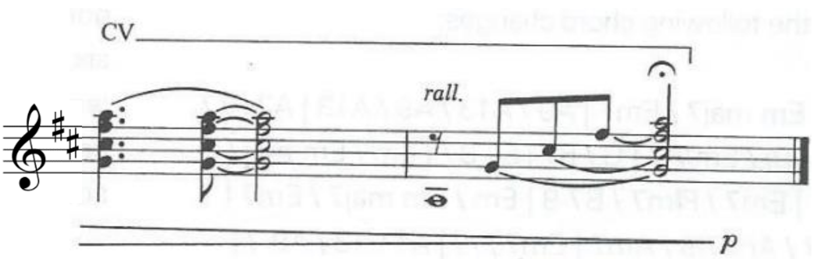
Although GSF's processing speed and attributed GS may be specific to the evolving experience of the listener, this bewildering array of options for this chord suggests that the processing would require longer than the single beat. The mystery chord is retrospectively understood to be functioning as B Dorian through the subsequent B melody note and familiar voice leading to E7(b9)/G# e.g., II-V in A major. Instead of continuing in A major, the A7sus4/G and A7/G chords in bar two suggest that E7(b9)/G# was functioning as V7/V (a secondary dominant) in D major.

Whereas the *g*1's of E7(b9)/G#, A7sus4/G, and A7/G are recognised with assistance from memory traces of preceding tones, the lack of clearly defined fundamental tones continues to be a problem throughout the piece. Notably, the first clear use of Ionian was arguably not intended by McDonough. Following A7/G, bars three and four further underline the dominant sound and an expectation to resolve to D Ionian (Imaj7 of D major).

As bar five of Mairants' (2002, pp. 52-55) transcription shows, II-7 (E-7 in D major) is traditionally the first chord of the *Honeysuckle Rose* (Razaf and Waller, 1929) melody. However, the expectation to resolve from V7 and the absence of E as a fundamental tone seemingly causes GSF to attribute D Ionian e.g., D = *g*1, G = AN11, A = T5, B = T13. The somewhat unusual registral position of B as the lowest of these tones indicates that McDonough intended E Dorian, in which B is a CT.

Beat three of bars five and six change the GS to A Mixolydian (V7 of D major). Because the A fundamental of this GS sustains into beat one of bars six and seven, it is negotiable whether Mixolydian continues, or the familiarity of the phrase recalls D Ionian. Furthermore, because G is the lowest tone introduced when the harmonic pattern theoretically repeats, G Lydian (IVmaj7 of D major) is also an option. Again, this plurality of options is symptomatic of an unclearly defined fundamental tone.

Another notable use of Ionian in McDonough's piece is in the perfect cadence that closes the piece, as shown in Example 4.3b.



Example 4.3b: The final two bars of McDonough's *Honeysuckle Rose* (1934), demonstrating a gradual(?) perfect cadence from A Mixolydian to D Ionian.

Unfortunately, this excerpt of the transcription (Mairants, 2002a, pp. 52-55) also contains two errors: the first chord should be G-D-F# (A7sus4/G); and the arpeggiated G-C#-F# in bar two should be F#-A-D, forming a D/A chord. Bar one, therefore, shows A7sus4/G (V7sus4 –

Mixolydian 7sus4) moving to A7(13)/G (V7 – Mixolydian). In contrast to this clear change of GS, the low A in the final bar suggests a continuation of A Mixolydian and staggers the cadence to D Ionian.

Akin to how the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) may be shaped to expect GS' corresponding to tonic chords for the beginning of pieces, listening experience of cadences naturally leads to expectations for the GS' of resolution. For Example 4.3b, the change from Mixolydian 7sus4 to Mixolydian and the duration afforded to the latter are highly typical of perfect cadences. Consequently, although it may represent a continuation of Mixolydian, it is negotiable that the A at the beginning of bar two is heard as scale degree 5 in D Ionian. If not, it seems likely that D Ionian would be attributed by the subsequent F# (3) due to the voice leading from G (-7) in A Mixolydian.

McDonough also briefly uses G Ionian, as shown in the third bar of Example 4.3c. Although the key is D major, the GS for IVmaj7 is G Ionian (not Lydian) when preceded by V7/IV – this is explained in section 'A.2.2: Secondary' of the Appendix by Nettles and Graf (1997).

Example 4.3c: An extract from McDonough's *Honeysuckle Rose* (1934), demonstrating V7/IV to IV in D Major.

It is negotiable whether both ‘D7’ chords share the Mixolydian / V7/IV function. This is because the latter is preceded by constant structures (see section ‘A.8.2: Constant Structures’) and may thus be interpreted as A°7(11). However, there are two reasons why this chord is more likely heard as D7 / Mixolydian / V7/IV: the memory trace of the first D7 chord, and the ‘Gm6’ and ‘G#°’ can also be interpreted as constant structures of the original D7/A chord e.g., C7/G and C#7/G#. Consequently, it is likely that GSF would attribute G Ionian to bar three. Unlike any occurrence of D Ionian, the clear fundamental tone perhaps demonstrates McDonough’s awareness of the potential negotiability.

McDonough’s piece has demonstrated Ionian via the lack of a clearly-defined fundamental bass, on tonic chords designated as such by perfect cadences and at the beginnings of pieces by the ‘sonic saddle’ (Shepherd and Wicke, 1997, pp. 174), and on IVmaj7 when it follows V7/IV. Of these uses, Reinhardt only makes negotiable use of Ionian at the beginning of his piece – as shown by Example 4.3d.

Example 4.3d: Bars 1-3 of Reinhardt’s *Echoes of Spain* (1939), demonstrating the negotiable attribution of Mixolydian (b9, #9, b13).

As discussed in section ‘3.9: Spectral Analysis: GSF for Tempered PT Combinations’, the spectra of the E major chord in bar one could correspond to either Ionian or Lydian. Nevertheless, as noted for the first chord of McDonough’s piece, a shaped ‘sonic saddle’

(Shepherd and Wicke, 1997, pp. 174) may expect tonic Ionian at the outset of the piece. However, if the listener is aware of the piece's name, then their prior experience of 'Spanish'-sounding music may lead them to attribute a 'Spanish'-sounding GS. If not for the major third (G#), Phrygian or harmonic minor could be options.

To house the major third, Mixolydian (b9, #9, b13) is an option that may be familiar to listeners through its independent usage to create a 'Spanish' sound and/or more commonly with the V7(b9) chord in a minor key e.g., E7(b9) in A Minor. Mixolydian (b9, #9, b13), as noted in section '4.2: GS Vocabulary' is the fifth mode of the harmonic minor scale with an extra note (#9). Whereas Ionian, Lydian, and Mixolydian (b9, #9, b13) are all viable options for bar one, the latter is confirmed for bar three. This is because the change to and from the Fmaj7(#11)/E chord in bar two indicates movement within the harmonic minor scale.

However, in the remainder of the piece, Ionian finds other ways to resurface. The first of these (demonstrated in Example 4.3e) is common in jazz music.

Example 4.3e: An extract from Reinhardt's *Echoes of Spain* (1939), demonstrating subV7 resolving to Imaj7.

The extract shows an F7/C chord resolving to an E major chord. As section 'A.2.4: Substitute' of the Appendix explains, F7/C is a substitute (subV7) for B7 (V7) in the key of E major and would be attributed with a Lydian b7 GS. This resolution makes E major a tonic

(Imaj7) chord with an Ionian GS. Example 4.3f demonstrates a less common (but equally intriguing) way in which Ionian resurfaces.

Example 4.3f: An extract from Reinhardt's *Echoes of Spain* (1939), demonstrating Ionian attribution in a weakened harmonic minor context.

This excerpt and several preceding bars evidence a weakening of the harmonic minor modes that predominate the piece. For example, the Eb and Bb in bars one and two, respectively, do not belong to A harmonic minor or E Mixolydian (b9, #9, b13). Consequently, whilst the G# leading note in bar three is resolved into the A of the C(13) chord in bar four, the C(13) is seemingly attributed with Ionian rather than Ionian (#5) (the equivalent harmonic minor mode). This is further confirmed by the strength of scale degree 5 (G) as a harmonic of the fundamental.

The uses of Ionian in Mastren's and Van Eps' pieces have largely been represented by the examples from McDonough's and Reinhardt's. In Mastren's piece, Ionian is always used on the tonic (A major and F major) and preceded by V7. Van Eps' use of Ionian is more varied but shares much in common with McDonough's: the piece opens with a major chord; regular perfect cadences to tonic major chords; and subV7 to tonic major chords. However, as Example 4.3g illustrates, the final bars of Van Eps' piece make use of Ionian in a way that is dissimilar to the pieces already discussed.

Example 4.3g: The final three bars of Van Eps' *Once in A While* (1949), demonstrating melodic and (negotiable) harmonic use of UT's in C Ionian.

C is heard as *g*1 throughout Example 4.3g with assistance from a bass line (not notated) and a perfect cadence from a G7(13) chord in the preceding bar. These factors ensure that there is minimal negotiation against C Ionian being attributed to the first bar and the majority of bar two. With the tempo circa 170bpm, the A# and D# chromatic passing notes do not have the duration to undermine the GS are instead heard as melodic UT's: A# = UT-7, D# = UT#9/-3.

Furthermore, it is negotiable that the F# on beat four of bar two belongs to Ionian. Although it is arguably perceived as T#11 in Lydian, the short duration of F# and the immediate memory of other UT's suggest that it may be heard as UT#11/b5 in Ionian.

Historically, there has been a greater melodic use (X axis) of UT's than harmonic (Y axis). This arguably represents a desire for the outer *g* values without the understanding of how their longer duration may / may not disturb a GS. As section '3.5: Upper Tensions' explained, harmonic use of the UT's requires the closer gravi-tones to be clearly defined in a relatively lower registral position e.g., CT's, T's, and (rarely) AN's.

For the first time in the analysis, the triplet in the second bar of Example 4.3g arguably demonstrates influence from the unified time dimension / Z axis by forming a 3:2 polyrhythm with the underlying quaver-feel. This would evoke scale degree 5 (*g*2) in Ionian – as explained in section '3.16: The Unified Time Dimension (Z Axis)'. Because 5 (G) also occurs as a present tone (bar two, beat two) and a strong partial of the fundamental, this Z axis contribution merely supports GSF's other qualities. For this era, only Van Eps applies the Z axis with Ionian.

Ionian maj7sus4: As noted in the analysis of Example 4.3e (an extract from Reinhardt's piece), E Ionian follows the F7/C (subV7) chord. However, whilst this is true for the E major chords, Ionian's AN11 (*g*7) does not reflect the closeness of A in the Esus4 chords on beat three of bars two and three. Like Mixolydian and Mixolydian 7sus4, Ionian requires a 'sus4' version: Ionian maj7sus4. Section '4.2: GS Vocabulary' calculated that A (sus4) and B (5) share *g*2 in E Ionian maj7sus4. This seems a more accurate reflection of A's relative distance in the Esus4 chords.

Dorian: Dorian is used in all the selected repertoire as the II-7 chord in a major key, most commonly in Mastren's and Van Eps' pieces. This usage is more limited in Reinhardt's piece due to the harmonic minor-related modes that dominate the piece e.g., the equivalent Dorian mode relative to A harmonic minor would be D Dorian (#11), which is not used anyway. McDonough's use of Dorian is also limited due to the lack of a clear fundamental bass, as discussed in the Ionian analysis. Nevertheless, the resultant negotiability means that a single context can effectively illustrate how II-7 chords can be prepared or recognised retrospectively.

The earlier analysis of Example 4.3a (bars 1-8 of McDonough's piece) explained that the first chord is retrospectively understood to be functioning as B Dorian through familiar voice leading to E7(b9)/G# e.g., II-7 to V7 in A major. As an aside, the implications of retrospective understanding for GSF are not clear. It may be that the GS corresponding to E7(b9)/G# is accompanied by a 'shadow' B Dorian GS (of indeterminate duration) that renews the perceived *g* values and interval structure of the preceding material. Equally, a retrospective understanding such as this may only entail the recognition of a functional relationship.

This bar is repeated in the outro of McDonough's piece. Whereas there was a multiplicity of GS options for the first chord in the introduction, the first chord of the outro is arguably heard as B Aeolian due to a clearly-defined key of D major. However, it is negotiable that the retrospectively understood use of B Dorian in the introduction is stored in the listener's long-term memory as a 'cue' (Deliége and Mélen, 1997, pp. 395) – as discussed in section '3.15: Memory and Time (T Axis)' – which acts as preparation for Dorian being immediately attributed in the outro. The chance of cue recognition is strengthened by the intro and outro sharing a half-time rubato-feel that is dissimilar from the rest of the piece.

In addition to its use on the II-7 chord, CST advises that Dorian occurs on minor seventh chords in 'nonfunctional relationships' (Nettles and Graf, 1997, pp. 162) – as noted in sections 'A.8: Nonfunctional Harmony', 'A.8.1: Contiguous Dominants', and 'A.8.2: Constant Structures'. However, Nettles and Graf do not clarify why Dorian receives preferential treatment over Aeolian and Phrygian, both of which also contain minor seventh CT's.

There is no answer to be found in the spectra of the minor seventh chord – as shown in the third table of Example 3.7c – which exhibit a remarkable degree of impartiality between these GS'. The weak MP's of Phrygian's ANb9 (Db), and Dorian and Aeolian's T9 (D) are perceptually indistinguishable from each other. Likewise, the characteristic ANb13 (Ab) of Aeolian and Phrygian, and T13 (A) of Dorian are both absent from the spectra.

This is a significant observation for minor seventh chords in 'nonfunctional relationships' *and* at the beginning of pieces. The spectral equivalence of Dorian, Phrygian, and Aeolian indicates that attributed GS is contingent on how each individual's 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) has been / is being shaped through their evolving listening experience.

Mirroring Ionian and the tonic major chord, listeners with experience of tonality may be more likely to attribute Aeolian to minor seventh chords at the beginnings and endings of pieces due to its tonic minor role. However, as section 'A.4: Minor Key Harmony' shows, Nettles and Graf (1997) interestingly position Dorian on the same plane as Aeolian for the I-7 chord. Dorian's 'victory' is arguably due to T13 bringing less of a challenge to GSF than the AN's of Aeolian or Phrygian, as argued in section '3.10: Spectral Analysis: *g* values'.

This may explain Dorian's popularity in the modal jazz movement e.g., *So What* (Davis, 1959b), *Cantaloupe Island* (Hancock, 1964) etc. Furthermore, this popularity may have led to a cultural shaping of the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) from which certain jazz audiences began to expect Dorian on minor seventh chords at the beginnings and endings of pieces.

For minor seventh chords in 'nonfunctional relationships' (Nettles and Graf, 1997, pp. 162), there are perhaps three reasons why CST points to Dorian. Firstly, with its association to the tonic minor chord, Aeolian would run the 'risk' of establishing a key centre. Secondly, the reduced challenge from Dorian's T13 (as noted above). Thirdly (and perhaps motivated by the first two reasons), continued usage of Dorian in 'nonfunctional relationships' shaping the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) to expect it.

Whilst there is only a single (and negotiable) use of Dorian in a 'nonfunctional relationship' (Nettles and Graf, 1997, pp. 162) by McDonough, it is relatively common in Reinhardt's, Mastren's, and Van Eps' pieces. Example 4.3h shows two such occurrences with an extract from Mastren's *Two Moods* (1945).

Example 4.3h: An extract from Mastren's *Two Moods* (1945), demonstrating the use of G and Bb Dorian through a departure from tonality.

The lack of relationship between the preceding material in A major and the first chord of the extract (more accurately written as G-7(9) – the root is supplied separately by the bass) means that the latter would be attributed with G Dorian. Similarly, Bb-7(9) would be attributed with Bb Dorian because it bears no functional relationship with G-7(9) except as a constant structure (explained in section 'A.8.2: Constant Structures'). The G-7(9) receives functional contextuality at the end of the extract as II-7 in F major.

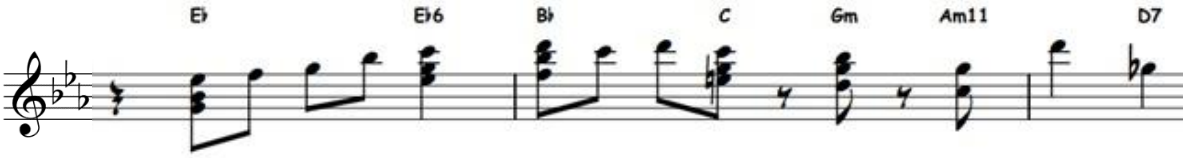
Dorian AN-7: Receiving light usage in McDonough's, Reinhardt's, and Van Eps' pieces, Dorian AN-7 is attributed to Dorian contexts where T13 is present but -7 is not. This is demonstrated in Example 4.3i with an A-(13) chord from Reinhardt's piece. According to CST (Nettles and Graf, 1997, pp. 79), the F# in this chord would replace G (-7) as a CT. However, it is contested here that the greater commonality of Dorian's -7 CT may condition the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) to hear F# as T13.

Example 4.3i: A chord from Reinhardt's *Echoes of Spain* (1939) that would be attributed with Dorian AN-7.

This is not to say that F# cannot assume the mantle of CT and produce an A-6 chord. Rather, it may require sufficient duration and contextualising use of other gravi-tones to be heard as such. For the chord in Example 4.3i, the semibreve duration and few Y axis-restricted gravi-tones arguably prevent this. This same logic arguably applies to other GS' that house T13 with CT potential. For example, in an Ionian or Lydian major sixth chord (e.g., A6 = A-C#-E-F#), F# is arguably heard as T13 but may become a CT with appropriate context. Although this structure occurs in the repertoire, the guise of the major sixth chord does not seem to.

For Dorian AN-7, T13's CT potential seemingly undermines the AN 'rule': 'nonchord tones which are a *half step above* a chord tone' (Nettles and Graf. 1997, pp. 26). In relation to Example 4.3i, this can be heard if the A (scale degree 1) at the top of the voicing is dropped to G (AN-7). Furthermore, despite having determined *g* values based on the CT configurations of the triad, how they are affected by -7's loss from the CT's is not entirely clear. It seems equally plausible the greater commonality of Dorian with a -7 CT conditions the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) to expect Dorian's *g* values and that AN-7 is simply an exception.

Phrygian: This GS only receives light usage on the III-7 chord of a major key in Reinhardt's and Van Eps' pieces. Example 4.3j shows one such occurrence in Van Eps' piece. The chord roots are supplied separately by a double bass. Although Eb and Bb are Imaj7 and V7 in Eb major, the subsequent changes suggest a modulation to F major e.g., Bb = IVmaj7 (Lydian), C = V7 (Mixolydian), G- = II-7 (Dorian), and A-7(11) = III-7 (Phrygian). Additionally, the change from A-7(11) to D7(b5) (Gb is Tb5) demonstrates a common 'abuse' of Phrygian to be retrospectively understood as Dorian e.g., II-V in G major.



Example 4.3j: An extract from Van Eps' *Once in A While* (1949), demonstrating the use of A Phrygian on the III-7 chord in F Major.

Lydian: Lydian plays a similarly minimal role to Phrygian in the selected repertoire. However, whilst Phrygian only occurs diatonically, Lydian occurs in three ways. Firstly, it may be attributed to the major chords that open Reinhardt's and Van Eps' pieces – as discussed in the Ionian analysis. Secondly, Lydian may be attributed diatonically e.g., IVmaj7 in a major key. Whether the fundamental tones are intentional or not (as argued in relation to Example 4.3a), this is most common in McDonough's piece. This usage occurs a mere handful of times in Van Eps' piece, once in Reinhardt's (noted in the Mixolydian analysis), and is absent from Mastren's.

Akin to Dorian and minor seventh chords, the third use of Lydian is for major seventh chords in 'nonfunctional relationships' (Nettles and Graf, 1997, pp. 162) – as noted in sections 'A.8: Nonfunctional Harmony', 'A.8.1: Contiguous Dominants', and 'A.8.2: Constant Structures'. The only explanation that Nettles and Graf offer for Lydian's victory over Ionian is that the former is 'best used' (pp. 169) when 'there is no specific tonic chord'. This infers that Ionian would 'risk' establishing a key centre, equivalent to Aeolian in minor contexts.

Three further arguments can be made in favour of Lydian for major seventh chords in 'nonfunctional relationships' (pp. 162). Firstly, Lydian's T#11 occurs with a relatively strong MP in the spectra of the major seventh chord – as observed in section '3.9: Spectral Analysis: GSF for Tempered PT Combinations'. Secondly, Dorian was deemed more appropriate for minor seventh chords in 'nonfunctional relationships' because, unlike Phrygian and Aeolian, it does not contain an AN. Whereas Ionian contains the particularly disruptive presence of AN11 (as argued in the Ionian analysis of section '3.10: Spectral Analysis: *g* values'), Lydian contains no AN's. Finally, like Dorian, continued use of Lydian in 'nonfunctional relationships' due to the aforementioned reasons may shape the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) to expect it.

The use of Lydian in 'nonfunctional relationships' (Nettles and Graf, 1997, pp. 162) is notably uncommon in the selected repertoire, occurring only once in Van Eps' piece – as shown in Example 4.3k. The roots are supplied separately by a double bass. A series of dominant chords prior to the extract means that there is no clear key centre. Although B-7 to E7(b9) is II-7 to V7 in A major, the subsequent changes represent a 'nonfunctional relationship'. Consequently, E-7 and F- would be attributed with Dorian, and Gmaj7(9) would be attributed with Lydian. The latter may be retrospectively understood as Ionian through the change to D e.g., Imaj7 to V7 in G major.

Example 4.3k: An extract from Van Eps' *Once in A While* (1949), demonstrating the use of G Lydian in a 'nonfunctional relationship' (Nettles and Graf, 1997, pp. 162).

Finally, only Van Eps engages the Z axis with Lydian. Akin to the Ionian usage in Example 4.3g, each Lydian use is simply a 3:2 polyrhythm (evoking scale degree 5) that supports GSF's other qualities.

Lydian (#9): This chromatically altered version of Lydian only occurs in Reinhardt's piece. Like Mixolydian (b9, #9, b13), Lydian (#9) is derived from the modes of the harmonic minor scale: Mixolydian (b9, #9, b13) is built from the fifth step (with the added #9) and Lydian (#9) is built from the sixth step.

As the analysis of Example 4.3d illustrated, Mixolydian (b9, #9, b13) is firmly attributed to the E major chord following the confirmation of movement within the A harmonic minor scale by the F(#11)/E chord. Equally, the movement from E major to F(#11)/E confirms a GS derived from the harmonic minor scale for the latter: F Lydian (#9). Although the lowest note of this chord is E, the arpeggiation through the remainder of the chord – particularly the fourth interval between C and F – confirm F as *g*1.

With similar assistance from preceding tones, Lydian (#9) is also attributed to other instances of F(#11)/E, an Fmaj7(#11), an F chord, and a lone F note. For each of these contexts, it is noteworthy that the chromatic alteration (#9) is derived purely from memory traces of the harmonic minor environment and never as a present tone.

Mixolydian: This GS corresponds to more harmonic contexts in functional relationships than any other, as detailed throughout the 'Appendix: The Attribution of GS' in Functional Relationships'. As a result (particularly given the general commonality of dominant seventh chords in jazz), Mixolydian is the most common GS across the selected repertoire. The pieces by McDonough, Mastren, and Van Eps all make regular use of Mixolydian on primary dominant chords. Examples 4.3a and 4.3b and the accompanying analysis illustrated this usage with McDonough's piece e.g., A Mixolydian = V7 of D major.

Perhaps due to the focus on the harmonic minor modes, Reinhardt's piece does not feature any V7 chords during the brief forays to major keys. However, Example 4.3l demonstrates how Reinhardt uses G Mixolydian as an equivalent to a primary dominant through the naturalisation of the harmonic minor environment.

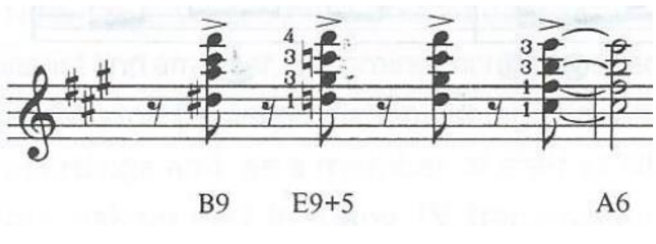
Example 4.3l: An extract from Reinhardt's *Echoes of Spain* (1939), demonstrating G Mixolydian as a 'primary dominant' through the naturalisation of the harmonic minor environment.

E Mixolydian (b9, #9, b13) (prior to the extract) and F Lydian (#9) (in bar one) are derived from the A harmonic minor scale. However, on beat one of bar two, the root of the G major chord converts A harmonic into A natural minor. Because the chord built on the seventh degree of A natural minor is equivalent to that built on the fifth of C major, the G major chord would be attributed with Mixolydian.

Nettles and Graf present Lydian b7 as the first option for the bVII7 chord, as shown in section ‘A.4: Minor Key Harmony’ of the Appendix. Whilst they do not provide an explanation, the choice of Lydian b7 may be to avoid the potentially tonicising effect that Mixolydian would have on the relative major key e.g., G Mixolydian tonicising C major.

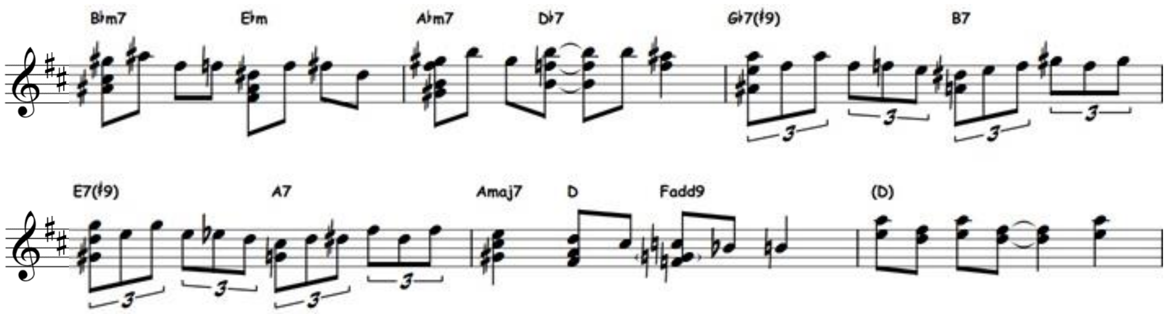
However, although E Mixolydian (b9, #9, b13) and F Lydian (#9) may be considered as modes of A harmonic minor, the emphasis on E Mixolydian (b9, #9, b13) marks it as the ‘key’. This reduces the likelihood of modulating to a relative major key and indicates that G Mixolydian is a better candidate than G Lydian b7. Note: the naturalising effect that G Mixolydian has on the A harmonic minor scale means that the subsequent F chord may be attributed with Lydian instead of Lydian (#9).

Mixolydian is also the GS for two unaltered secondary dominant chords: V7/IV and V7/V. V7/IV has already been demonstrated by Example 4.3c (an extract from McDonough’s piece) and the accompanying analysis. Example 4.3m is an extract from Mastren’s piece that demonstrates V7/V in A major e.g., B7(9) = V7/V, E7(b13/9) = V7, A(13) = Imaj7 (tonic). The root notes are supplied separately by a double bass.



Example 4.3m: An extract from Mastren’s *Two Moods* (1945), demonstrating a secondary dominant (V7/V) in A Major.

Both Mixolydian-functioning secondary dominants occur in McDonough's piece, only V7/V in Mastren's, and neither in Reinhardt's nor Van Eps'. For Reinhardt's piece, this may again be accredited to the focus on the harmonic minor modes. For Van Eps' piece, on the other hand, it is due to limited time spent within each key and how potential secondary dominants tend to be drafted into sequential dominant sequences (see section 'A.2.3: Sequential') that approach new keys. This is illustrated in Example 4.3n. The root notes are supplied separately by a double bass.

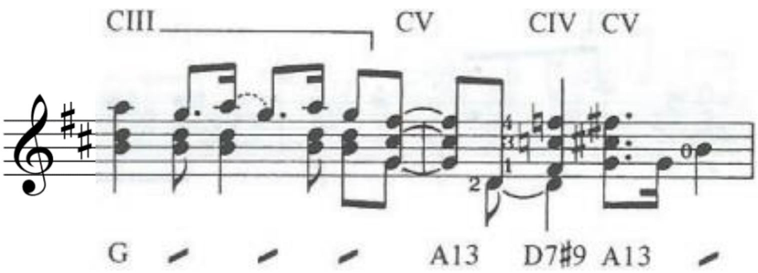


Example 4.3n: An extract from Van Eps' *Once in A While* (1949), demonstrating how a potential secondary dominant chord (Gb7(#9) = V7/IV in Gb Major) is drafted into a sequential dominant sequence that ends without a perfect cadence.

Gb7(#9) is prepared as V7/IV in Gb major by the II-V in the preceding bar. However, instead of acting as V7/IV with a resolution to Db, Gb7(#9) initiates a sequential dominant pattern that ends without a perfect cadence. The secondary dominant (present) and sequential dominant (retrospective) readings of Gb7(#9) result in the same GS: Mixolydian (#9). If not for the #9 alteration, both would be Mixolydian. Akin to the primary dominant, V7/IV, and V7/V, unaltered sequential dominant chords use Mixolydian e.g., B7 and A7 in Example 4.3n. Sequential dominant sequences are common to all four pieces.

Finally, Reinhardt's and Van Eps' pieces both arguably demonstrate the Z axis for Mixolydian with the same 3:2 polyrhythms as Ionian (as shown in Example 4.3g) and Lydian. These evoke scale degree 5 and simply support GSF's other qualities.

Mixolydian (#9): This GS only occurs several times in McDonough and Van Eps' pieces. As shown by the altered ladder of fifths (Example 4.2b), the #9 alteration is unique because it does not bring additional alterations from the spectra. The repertoire arguably displays an intuitive awareness of this 'privilege' through #9 never occurring in the company of other alterations. The lone 7(#9) chord that occurs in McDonough's piece is shown in Example 4.3o.



Example 4.3o: An extract from McDonough's *Honeysuckle Rose* (1934), demonstrating Mixolydian (#9) on V7/IV (D7(#9)) in D Major.

D7(#9) is functioning as V7/IV (secondary dominant) in D major, albeit without a resolution to a G major chord. Because the appropriate GS for V7/IV is Mixolydian, the #9 alteration would result in Mixolydian (#9) being attributed. Van Eps' use of Mixolydian (#9) has already been illustrated by the sequential dominant sequence of Example 4.3n and the accompanying analysis. This usage occurs several times across the piece. Mixolydian (#9) may also correspond to the I7 chord in a blues functional relationship (see section 'A.5: Blues Chord Scales') but this does not occur in the repertoire.

Finally, Van Eps arguably demonstrates the Z axis for Mixolydian (#9) with the same 3:2 polyrhythms as Ionian (as shown in Example 4.3g), Lydian, and Mixolydian. These evoke scale degree 5 and simply support GSF's other qualities.

Mixolydian (b13): This GS can occur in three ways: (1) as the diatonically-appropriate GS for V7/II in a major key and V7 in a minor key; (2) if ♮9 as a present tone negates the b9 and #9 of a diatonic context (e.g., Mixolydian (b9, #9, b13) for V7/III); and (3) if ♮9 as a present tone negates the #9 brought from the harmonic series of the b13 alteration, as shown by the altered ladder of fifths (Example 4.2b).

Mixolydian (b13) is not used in McDonough's piece. However, through the second method of attribution, it is identifiable in the pieces by Reinhardt, Mastren, and Van Eps. Example 4.3p shows an extract from Van Eps' piece that handily demonstrates spectral influence and denial for a sequential dominant chord, A7(b13/9). The root notes are supplied separately by a double bass.

Example 4.3p: An extract from Van Eps' *Once in A While* (1949), demonstrating spectral influence and denial in the ultimate attribution of Mixolydian (b13).

Because 9 (B) occurs after the initial chord structure, the b13 (F) would bring an unchallenged #9 alteration for GSF's consideration. This would result in an A Mixolydian (#9, b13) GS. Once 9 is present, however, #9 is negated and the GS is exchanged for A Mixolydian (b13). Arguably due to intuitive recognition of this extra work for GSF, all other occurrences of Mixolydian (b13) across the repertoire bring ♮9 from the outset.

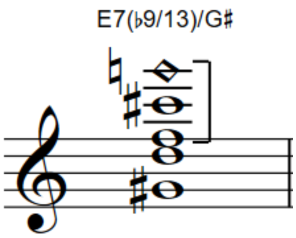
Mixolydian (b9, #9): This GS is not included in any section of the Appendix as a diatonically-appropriate GS. Furthermore, it brings an additional shade of grey to the altered ladder of fifths (Example 4.2b) via the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174). The preceding analysis of Mixolydian (b13) illustrated that the altered ladder of fifths may be denied by ♮9 as a present tone. Because the ladder shows that b9 brings both b13 and #9, this would suggest that Mixolydian (b9, #9) may be attributed through the joint presence of ♮13 and b9.

However, it is possible that GSF may process this combination of tones in two different ways. Firstly, #9 (the top rung of the ladder) may be inaudible because it does not make a fifth interval with ♮13. This would lead GSF to attribute a Mixolydian (b9) GS. Secondly, it is possible that the 'sonic saddle' of listeners with sufficient experience may be shaped to circumvent the ‘broken rung’ of the ladder. In other words, it may be possible to perceptually insert #9 through its learned association with b9. This would result in a Mixolydian (b9, #9) GS.

All the analysis in this Chapter assumes the listener’s knowledge of the ladder, as stated in section ‘4.2: GS Vocabulary’. For the sake of consistency, it will be assumed that the listener is similarly capable of circumventing this ‘broken rung’. Not unlike Mixolydian (b13), Mixolydian (b9, #9) may also occur if ♮13 negates the b13 in a diatonic context (e.g., Mixolydian (b9, #9, b13) for V7/III). However, the few attributions of this GS in the selected repertoire – by McDonough, Mastren, and Van Eps – are all through challenging the altered ladder of fifths.

In a similar way to the A7(b13/9) chord in Example 4.3p, the E7(b9)/G# chord in the first bar of McDonough’s piece (shown in Example 4.3a) illustrates both spectral influence and denial. As stated earlier, E7(b9)/G# would likely be heard as V7 in A major. Because the b9 alteration would bring b13 and #9 from the altered ladder of fifths, the chord would be attributed with E Mixolydian (b9, #9, b13).

However, the subsequent C# (♮13) in the melody would negate the b13 of the GS. Whilst the ♮13 breaks the b13 rung in the altered ladder of fifths, a listener with sufficient experience would arguably be able to perceptually insert #9 (G) from the b9 (F) as a present tone – as illustrated by Example 4.3a cont. 2. Therefore, the attributed GS would be E Mixolydian (b9, #9).



Example 4.3a cont. 2: A chord from Example 4.3a, the introduction of McDonough's *Honeysuckle Rose* (1934). It illustrates how listening experience of the altered ladder of fifths may enable a perceptual linkage from b9 (F) to #9 (G) despite a 'broken rung' in the ladder e.g., ♮13 / C# in place of b13 / C.

Mixolydian (#9, b13): It is interesting that this GS is neglected by CST (it does not appear in the Appendix) because it may be attributed in four ways: (1) to Mixolydian contexts where ♮9 is not a present tone but b13 as an altered present tone brings #9 from the spectra, as shown by the altered ladder of fifths (Example 4.2b); (2) to Mixolydian contexts with b13 and #9 as altered present tones; (3) to Mixolydian (b13) contexts with #9 as an altered present tone; and (4) to Mixolydian (#9) contexts (e.g., I7 in a blues) with b13 as a present tone.

However, CST's neglect may be explained by Mixolydian (#9, b13)'s rarity. Across the selected repertoire, it is only used occasionally in Reinhardt's, Mastren's, and Van Eps' pieces via the first attribution method. Example 4.3p and the accompanying analysis have already demonstrated this usage in Van Eps' piece.

Finally, Reinhardt arguably demonstrates the Z axis for Mixolydian (#9, b13) with the same 3:2 polyrhythms as Ionian (as shown in Example 4.3g), Lydian, Mixolydian, and Mixolydian (#9). These evoke scale degree 5 and simply support GSF's other qualities.

Mixolydian (b9, #9, b13): The attribution methods of this GS may be split into two categories. Firstly, it may occur as the diatonically-appropriate option for: V7/III and V7/VI in a major key, V7/II in a blues, and V7(b9) in a minor key / fifth mode of harmonic minor with an extra note (#9). Secondly, as shown by the altered ladder of fifths (Example 4.2b), b9 can also bring b13 and #9 through the spectra. Therefore, so long as ♮13 and ♮9 are not present tones, a lone b9 alteration may be sufficient to attribute Mixolydian (b9, #9, b13) in Mixolydian, Mixolydian (#9), and Mixolydian (b13) contexts.

Reinhardt's usage of Mixolydian (b9, #9, b13) in modal relation to the harmonic minor scale has already been demonstrated by Example 4.3d and the accompanying analysis. It was also discussed how a listener may interpret this GS as 'Spanish'-sounding. By extension, this interpretation may lead them to project the *g* values onto an associated physical schema (as discussed in section '3.20: Conceptual Metaphor') e.g., bullfighting stadia, a flamenco dance, the Sagrada Familia etc. In the case of the latter, for example, the fundamental / *g*1 may be mapped to the ground and the outermost *g* values (UT#11/b5 and UT6/13/°7 jointly occupy *g*11) to the two tallest spires.

The related diatonic use of Mixolydian (b9, #9, b13) on V7(b9) in a minor key can be found in Van Eps' piece. Example 4.3q is in F minor with brief use of C Mixolydian (b9, #9, b13) on C7(b9). The root notes are supplied separately by a double bass.

Example 4.3q: An extract from Van Eps' *Once in A While* (1949), demonstrating Mixolydian (b9, #9, b13) on V7(b9) in a minor key.

This may also be considered as equivalent to V7/VI in Ab major, which is otherwise not demonstrated in the repertoire. V7/III can be found in Mastren and Van Eps' pieces whereas V7/II in a blues is absent due to the lack of blues progressions. The alternative spectral route to Mixolydian (b9, #9, b13) used lightly by McDonough and Reinhardt but is a regular feature of Van Eps' piece. It has already been demonstrated in the Mixolydian (b9, #9) analysis in reference to McDonough's piece and Example 4.3a.

Finally, Mastren arguably demonstrates the Z axis for Mixolydian (b9, #9, b13) with the same 3:2 polyrhythms as Ionian (as shown in Example 4.3g), Lydian, Mixolydian, Mixolydian (#9), and Mixolydian (#9, b13). These evoke scale degree 5 and simply support GSF's other qualities.

Mixolydian 7sus4: This GS is used in all pieces except Mastren's. McDonough's usage of this GS has already been noted as part of the Example 4.3a analysis (Ionian section). Whilst Van Eps' use is similar to McDonough's, Reinhardt's is more negotiable. It was argued in relation to Example 4.3e that the Esus4 chords would be attributed with Ionian maj7sus4 because of the preceding subV7 (F7) and tonic major (E) chords.

However, an alternative reading of this context would be that the subV7 chord is not sufficient to disturb Mixolydian (b9, #9, b13)'s well-established authority as tonic. Consequently, the Esus4 chord may inhabit a Mixolydian environment: Mixolydian 7sus4. It is also negotiable whether the alterations of Mixolydian (b9, #9, b13) would be carried to Mixolydian 7sus4. However, the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) may have been shaped to expect the unaltered form from the typicality of its use – also note that no altered forms of Mixolydian 7sus4 appear in the Appendix.

Mixolydian 7sus4 (b13): Whilst the above argument suggests that altered forms of Mixolydian 7sus4 are less likely from memory traces of preceding tones, Van Eps' piece demonstrates how they might be achieved with present tones. Example 4.3r shows II-7 to V7 in D major with the roots supplied separately by a double bass. Although the A7sus4(13) that concludes the bar would be attributed with Mixolydian 7sus4, the preceding A7sus4(b13) requires an altered form: Mixolydian 7sus4 (b13). As noted in the spectral analysis of section '4.2: GS Vocabulary', this GS is unusual because the b13 alteration also represents an AN.

Example 4.3r: An extract from Van Eps' *Once in A While* (1949), demonstrating Mixolydian 7sus4 (b13) on V7sus4(b13).

Aeolian: This GS occurs in all but McDonough's piece as the VI-7 of major keys and/or the tonic of a minor key. The former only receives limited usage in Reinhardt's and Van Eps' pieces. In Reinhardt's piece, a VI- chord can be found in the four-bar progression of Example 4.3s: E | C#-/G# | B-/F# | C#-/G#.

Example 4.3s: An extract from Reinhardt's *Echoes of Spain* (1939), demonstrating Aeolian attribution to VI-7 (C#-/G#) of a major key (E).

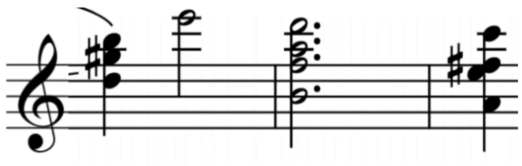
Following E, C#-/G# would be heard as VI-7 of E major and attributed with Aeolian. Interestingly, however, the subsequent change to B-/F# unhinges the E major context. This chord may be attributed with either Dorian as a 'nonfunctional' (Nettles and Graf, 1997, pp. 162) minor or Aeolian as a constant structure of the preceding C#-/G# chord. The second C#-/G# chord creates even more negotiability as it may be attributed with: Dorian through constant structure if B-/F# was perceived as such; Phrygian as III7- of A major if B-/F# is retrospectively understood as II-7; or Aeolian through a perceived return to the first use.

Aeolian as tonic receives similarly limited usage in Reinhardt's, Mastren's, and Van Eps' pieces. As noted in the Dorian analysis, listeners with experience of tonality may have their 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) shaped to attribute Aeolian to minor seventh chords at the beginning of pieces. This logic may be extended to minor chords that follow cadences. Again, Example 4.3t shows an excerpt from Reinhardt's piece that is interesting through negotiability.

Example 4.3t: An extract from Reinhardt's *Echoes of Spain* (1939), arguably demonstrating Aeolian as tonic (A-).

The A- chord that concludes the passage is arguably attributed with Aeolian due to the cadence from the Bb7(9) chord (subV7 in A Minor) in the preceding bar. However, there are two other possible GS' for A-. Firstly, Dorian may assume a tonic minor role – as discussed in the Dorian section. Secondly, A- may be attributed with harmonic minor due to the modal environment that has been regularly referenced throughout the analysis. This is emphasised by the Ab (seventh degree of the A harmonic minor scale) of the Bb7 and Bb7(9) that resolves into A♮. However, it may also be argued that the G# is resolved and thus not carried to A- as a maj7 CT for harmonic minor.

Locrian: Considering Locrian is diatonic to the major and natural minor scales, it is perhaps surprising to find that it only occurs once across the four pieces. This occurrence is shown in Example 4.3u, an extract from Reinhardt's piece. From all GS' introduced thus far, the B-7b5 in bar two only correlates with the CT's of Locrian. Additionally, the E7 and A-6 (Dorian tonic) chords in bars one and three, respectively, confirm that B-7b5 is heard as II-7b5 in A Minor (equivalent to VII-7b5 in C major).



Example 4.3u: An extract from Reinhardt's *Echoes of Spain* (1939), demonstrating Locrian attribution to II-7b5 (B-7b5) of A Minor.

In section 'A.4: Minor Key Harmony' of the Appendix, CST advises that Locrian (♮9) is also an option for II-7b5. However, where ♮9 is absent, Locrian is the 'better-fit' for two reasons: Locrian's ANb9 (e.g., Db in C as *g*1) has a greater presence in the spectra of the -7b5 than ♮9 (D) (see third table of Example 3.7c); and only Locrian fits diatonically with the major and natural minor scales.

Lydian b7: Like Mixolydian, Lydian b7 may be attributed to many harmonic contexts – as detailed in the Appendix. However, the many contexts of these GS' are distinguished by one simple rule: 'Chords using Mixolydian or any form of altered Mixolydian are expected to resolve down a perfect 5th; chords using Lydian b7 are expected to resolve with root motion not down a perfect 5th' (Nettles and Graf, 1997, pp. 58).

Whilst Mixolydian and its altered forms dominate the selected repertoire, Lydian b7 also surfaces several times in each piece. It has already been demonstrated by Examples 4.3l and 4.3e and their accompanying analysis. The Bb7 and Bb7(9) chords in Example 4.3t are also representative of Lydian b7 attribution to subV7. Example 4.3v is an extract from Mastren's piece that illustrates multiple facets of Lydian b7 attribution and how it may often be shrouded with negotiability. The root notes are supplied separately by a double bass.

Example 4.3v: An extract from Mastren's *Two Moods* (1945), demonstrating the attribution of Lydian b7 to 'nonfunctional' (Nettles and Graf, 1997, pp. 162) and sequential substitute dominant seventh chords.

The G7(9/#11) chord bears no functional relationship with the preceding Db-7(9). As Nettles and Graf (1997) state in sections 'A.8: Nonfunctional Harmony', 'A.8.1: Contiguous Dominants', and 'A.8.2: Constant Structures', Lydian b7 is the appropriate GS for dominant seventh chords in 'nonfunctional relationships' (pp. 162). The same yardsticks used to assess of Dorian and Lydian's 'nonfunctional' victories also apply to Lydian b7.

Firstly, Lydian b7 is not 'expected to resolve down a perfect 5th' (pp. 58) and thus does not carry the functional baggage of Mixolydian or its altered forms. Secondly, unlike Mixolydian, Lydian b7 is not burdened with an AN to challenge its attribution via GSF. Thirdly, and perhaps due to the first two arguments, continued use of Lydian b7 in 'nonfunctional relationships' (pp. 162) may shape the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) to expect it.

Interestingly, however, the spectral content of the dominant seventh chord (shown in Example 3.7c) does not support Lydian b7's victory: Mixolydian's F (AN11) occurs with SP (deriving its presence as a harmonic of Bb / -7) whereas Lydian b7's F# (T#11) is absent. This spectral conundrum in Lydian b7's 'victory' suggests that there may be greater negotiability for ‘nonfunctional’ (Nettles and Graf, 1997, pp. 162) dominant seventh chords than other chord qualities.

In Example 4.3v, the C# (T#11) in G7(9/#11) is representative of Lydian b7 and rules out Mixolydian. However, G7(9/#11) also introduces a sequential substitute progression (see section ‘A.2.5: Sequential Substitute’) that is more open to debate. The GS ‘for each chord is determined by either chromatic sound or dominant function’ (Nettles and Graf, 1997, pp. 62). Because G7(9/#11) does likely not carry the ‘dominant function’ of Mixolydian, the subsequent F#7(9) may likewise share Lydian b7.

Alternatively, Db-7(9) and F#7(9) may be heard as II-7 to V7 in B major with G7(9/#11) as a chromatic stepping stone (subV7/II). The resultant Mixolydian GS for F#7(9) would be supported by the B (AN11) in the spectra. By the F7(9/b13) chord, two factors indicate a swing in the Lydian b7 / Mixolydian balance. Firstly, the pedal C# in the melody of the whole sequential substitute progression creates anticipation and thus an expectation ‘to resolve down a perfect 5th’ (pp. 58).

This is substantiated by the b13 alteration which – despite the Lydian b7 (b13) GS ‘incorrectly’ derived from the harmonic series in section ‘3.8: Spectral Analysis: GSF for the Single Tone’ – is atypical of Lydian b7. Lydian b7 (#9) is the only chromatically altered form to be found in the Appendix. Moreover, Lydian b7 (b13) seems potentially uncommon due to the consecutive semitones between T#11, 5, and Tb13. The resulting F Mixolydian (b13) GS would carry the expectation for resolution ‘down a perfect 5th’ to E7(9/13) (Mixolydian), which ultimately resolves to A Ionian in the following bar.

Finally, Van Eps arguably demonstrates the Z axis for Lydian b7 with the same 3:2 polyrhythms as Ionian (as shown in Example 4.3g), Lydian, Mixolydian, Mixolydian (#9), Mixolydian (#9, b13), and Mixolydian (b9, #9, b13). These evoke scale degree 5 and simply support GSF’s other qualities.

Lydian b7 (#9): As noted above, Lydian b7 (#9) is perhaps the only common altered form of Lydian b7. It is attributed to Lydian b7 contexts (i.e., dominant seventh chords with no expectation to resolve down a perfect 5th) with a #9 alteration as a present tone. In the selected repertoire, Lydian b7 (#9) can only be found once apiece in Reinhardt's and Van Eps' pieces.

Van Eps uses it to conclude his piece, as shown in Example 3.4g. The preceding Ionian GS with the same *g*1 arguably suggests that the C7(13/#9) might be heard as V7/IV / Mixolydian (#9). However, Lydian b7 (#9) is the more likely option due to the general sense of closure achieved by preceding cadences, melodic climax (including UT's), and C7(13/#9)'s staccato duration.

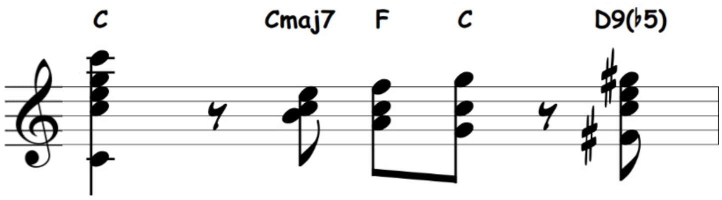
altered: When there is expectation for a dominant seventh chord to resolve down a perfect 5th, a lone b5 alteration may also bring b9, b13, and #9 from the spectra – as shown by the altered ladder of fifths (Example 4.2b). The resulting altered GS is only identifiable once in Reinhardt's piece and twice in Van Eps', perhaps indicating an intuitive respect for this maximally-altered form of Mixolydian. Example 4.3w shows the usage with an E7no5(b5) chord (bar two, beat three). Although the 'E7no5(b5)' symbol may seem clumsy, the 'no5' indicates 5's absence from the dominant seventh CT's and '(b5)' indicates Tb5.

Example 4.3w: An extract from Reinhardt's *Echoes of Spain* (1939), demonstrating the attribution of altered via the altered ladder of fifths (Example 4.2b) to an E7no5(b5) chord.

The Reinhardt example was selected because it is illustrative of how minimal present tones can achieve multiple chromatic alterations. As already discussed, the E major chord (bar two, beat two) would correspond to Mixolydian (b9, #9, b13) as the fifth mode of harmonic minor with an extra note (#9). The altered set is then completed by the lone b5 present tone in the E7no5(b5) chord.

altered (♮9): This GS occurs on dominant seventh chords expected to resolve down a perfect 5th with both b5 and ♮9 as present tones. Like Mixolydian (b9, #9), altered (♮9) is the product of circumventing a 'broken rung' in the altered ladder of fifths (Example 4.2b). The ♮9 present tone in the company of b5 neutralises the potential b9 and #9 alterations, thus breaking the b9 rung between b5 and b13. However, as argued in with Mixolydian (b9, #9), a listener with sufficient experience of the altered ladder of fifths may be able to perceptually insert b13 from its learned association with b5.

Altered (♮9) only receives brief usage Van Eps' piece, as demonstrated by the D7no5(9/b5) chord in Example 4.3x. The root is supplied separately by a double bass.



Example 4.3x: An extract from Van Eps' *Once in A While* (1949), demonstrating the attribution of altered (♮9) to 'D9(b5)' / D7no5(9/b5).

The expectation for resolution (and attribution of altered (♮9)) comes from D7no5(9/b5)'s potential identity as V7/V in C major. This is supported by its metric position, the preceding subdominant (IV) F chord, and the perfect cadences in most bars of Van Eps' piece. If these factors do not lead to the expectation for resolution, however, then the chord may be interpreted as D7(9/#11) and attributed with Lydian b7.

Additionally, it may be observed that the CT's and T's of altered (♮9) form a whole-tone scale with a different chord scale formulation (discussed in section '3.14: GS Subsets and 'Exotic' Scales') to whole-tone +7 and whole-tone 7b5. This may indicate that whole-tone 7b5 is an option for the chord in Example 4.3x. However, b5 is arguably assured as altered (♮9)'s T rather than whole-tone 7b5's CT by the V7/V context.

melodic minor: As section 'A.4: Minor Key Harmony' shows, CST positions melodic minor as the GS for the I-6, I-maj7, and IV-6 chords. Perhaps in accordance with I-maj7, the three occurrences of melodic minor in the selected repertoire – twice in Van Eps' piece and once in Reinhardt's – are all 'nonfunctional' (Nettles and Graf, 1997, pp. 162) with their preceding material. Example 4.3y shows one of the occurrences in Van Eps' piece.

Example 4.3y: An extract from Van Eps' *Once in A While* (1949), demonstrating the attribution of melodic minor to C-maj7(9).

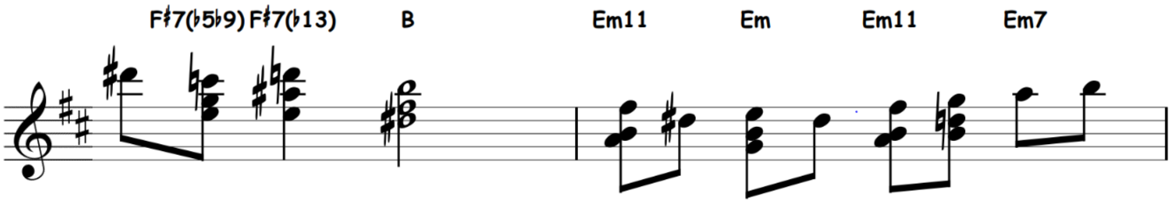
Bar two shows II-7 to V7 in Bb major in which the II-7 chord (usually Dorian) has been substituted for C-maj7(9). Because C-maj7(9) and F7(9) are both diatonic to the C melodic minor scale as I-maj7 and IV7 (as shown in section ‘A.7: Modal Interchange’), the C-maj7(9) chord that follows F7(9) is highly likely to be attributed with a C melodic minor GS. However, the GS for C-maj7(9) at the start of bar two is more negotiable due to the lack of functional relationship with the preceding A7.

The tones of C-maj7(9) may correspond to either melodic minor or harmonic minor. To assess which is the more ‘correct’ option, similar yardsticks may be used as for Dorian, Lydian, and Lydian b7’s ‘nonfunctional’ (Nettles and Graf, 1997, pp. 162) victories. Firstly, in section ‘A.4: Minor Key Harmony’, CST positions both as options for the I-maj7 chord, suggesting that they present equal ‘risk’ of tonicisation in a ‘nonfunctional’ context. However, the typicality of the harmonic minor scale in minor key perfect cadences may suggest it presents more-so.

Secondly, whereas harmonic minor contains ANb13, the lack of AN in melodic minor indicates it may be the more favourable option in ‘nonfunctional’ contexts. Thirdly, the spectral content of the -maj7 chord (see third table of Example 3.7c) is a ‘dead heat’: both harmonic minor’s ANb13 (Ab) and melodic minor’s T13 (A) are absent.

Finally, melodic minor’s lesser tonic potential and lack of AN may have resulted in continued ‘nonfunctional’ use that has shaped the ‘sonic saddle’ (Shepherd and Wicke, 1997, pp. 174) to expect it. The spectral equivalence, however, allows for negotiability. Therefore, melodic minor seems the likely option for the C-maj7(9) chord in Example 4.3y but harmonic minor appears to be a possibility.

harmonic minor: This GS only occurs in Reinhardt’s and Van Eps’ pieces. Its usage has already been discussed in relation to Example 4.3t and Example 4.3y. Additionally, however, Van Eps' piece highlights a problematic but important consideration with harmonic minor attribution – as shown in Example 4.3z.



Example 4.3z: An extract from Van Eps' *Once in A While* (1949), demonstrating the negotiable attribution of E harmonic minor to the X axis expression of the leading note (D#).

The cadence in bar one confirms the E-7(11/9) in the first quaver of bar two as tonic. As discussed in the Dorian section, this may be Aeolian or Dorian depending on the evolving experience of the listener. Regardless, the subsequent D# is where the problem lies. As a maj7 interval above E, this could convert the harmony to E-maj7(11/9) to which harmonic minor (or melodic minor) may be attributed.

In Example 4.3y, the maj7 interval of C-maj7(9) is positioned on the Y axis with the other gravi-tones. Contrastingly, the D# of Example 4.3z is interspersed between the other gravi-tones on the X axis and may thus sound as an unresolved leading note in the harmonic minor scale. Whilst an E harmonic minor GS remains possible, the D# may appeal to our prior listening experience of the leading note in minor contexts – as shaped by the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174). Consequently, a perfect cadence may be expected from the GS corresponding to the V7 (B Mixolydian (b13)) or V7(b9) (B Mixolydian (b9, #9, b13)) chords.

Summary: This analysis of ‘The 1930’s and 40’s’ chord-melody jazz guitar repertoire has brought several aspects of Gravi-Tone Series Filtering into sharper focus. The analysis tended to be dominated by the many nuances of functional relationships, illustrating the significance of GSF’s first (present tones) and third (memory traces of preceding tones) qualities.

GSF’s second quality (harmonic spectra) had a more sporadic influence which was discussed: for chords at the beginning of pieces (e.g., the discussion of McDonough’s and Reinhardt’s in Example 4.3a and 4.3d, respectively); as a yardstick to identify the ‘correct’ GS’ for chords in ‘nonfunctional relationships’ (Nettles and Graf, 1997, pp. 162), which only served as evidence for Lydian’s attribution to major seventh chords; and for the many chromatically altered Mixolydian GS’ which are attributed via the altered ladder of fifths (Example 4.2b).

GSF’s fourth quality (the unified time dimension / Z axis) was almost a non-factor across the whole analysis. Whilst it had presence via the 3:2 polyrhythms of Ionian (as shown in Example 4.3g), Lydian, Mixolydian, Mixolydian (#9), Mixolydian (#9, b13), Mixolydian (b9, #9, b13), and Lydian b7, the evoked scale degree 5 – a CT in each of these GS’ – never had a bearing on GSF.

Finally, and perhaps most significantly, several observations were made about how the ‘sonic saddle’ (Shepherd and Wicke, 1997, pp. 174) may be shaped at a cultural level i.e., the ‘Western listener’. These included: the altered ladder of fifths; the attribution of Ionian and Aeolian to tonic major and minor chords, respectively; Dorian’s tonic minor potential amongst jazz fusion audiences; and, in ‘nonfunctional relationships’ (Nettles and Graf, 1997, pp. 162), the attribution of Dorian to minor seventh chords (-7), Lydian to major seventh (maj7), Lydian b7 to dominant seventh (7), and (arguably) melodic minor to minor major seventh (-maj7).

4.4: ***Virtuoso* (Pass, 1973b) to Present**

The selected repertoire for the '*Virtuoso* (Pass, 1973b) to Present' era includes: Joe Pass' solo arrangement of *Have You Met Miss Jones?* (1973a); the chord-melody sections (intro and outro) of Allan Holdsworth's original composition *Looking Glass* (1986), accompanied by keyboard, bass, and drums; the melody sections of Ben Monder's original composition *O.K. Chorale* (1996), mostly accompanied by bass and drums; and Pasquale Grasso's solo arrangement of *Have You Met Miss Jones?* (2016).

4.5: GS Vocabulary

Example 4.14a shows the GS' that GSF may attribute across the duration of each piece. The GS' in Pass' and Grasso's pieces generally serve to construct tonal relationships. Contrastingly, those in Monder's and Holdsworth's pieces predominantly form 'nonfunctional relationships' (Nettles and Graf, 1997, pp. 162), with limited and negotiable instances of tonality. This distinction is evident from the GS vocabulary.

		REPERTOIRE			
		Joe Pass: *Have You Met Miss Jones?* (1973a)	Allan Holdsworth: *Looking Glass* (1986)	Ben Monder: *O.K. Chorale* (1996)	Pasquale Grasso: *Have You Met Miss Jones?* (TRENIER GUITARS, 2016)
GRAVI-TONE SERIES'	Ionian	✓	✓	✓	✓
	Ionian maj7sus4		✓	✓	
	Dorian	✓	✓	✓	✓
	Dorian AN-7		✓		
	Phrygian	✓	✓	✓	✓
	Lydian	✓	✓	✓	✓
	Mixolydian	✓			✓
	Mixolydian 7sus4	✓	✓	✓	
	Aeolian	✓	✓	✓	✓
	Locrian	✓			✓
	Lydian b7	✓			✓
	altered				✓
	melodic minor	✓			✓
	harmonic minor				
	whole-tone +7				✓
	whole-tone 7b5				✓
	symmetric dominant				
	symmetric diminished				
	chromatically altered chord scale GS'	Mixolydian (#9) Mixolydian (b13) Mixolydian (b9, #9) Mixolydian (#9, b13) Mixolydian (b9, #9, b13) Lydian b7 (#9)	Dorian (b9) Dorian (#11)	Lydian (b9) Lydian (#5) Lydian (b13)	Mixolydian (#9) Mixolydian (b13) Mixolydian (b9, #9) Mixolydian (#9, b13) Mixolydian (b9, #9, b13)

Example 4.5a: The GS' that GSF may attribute across the duration of the selected repertoire for the '*Virtuoso* (Pass, 1973b) to Present' era.

Whereas Pass and Grasso use sixteen and seventeen GS', respectively, Holdsworth and Monder each only use ten. Not only does this illustrate the complexity of the tonal system, but also the potential restrictions of 'nonfunctional' environments. The latter will receive attention in the following section. Armed with the tonal system, Pass and Grasso use Mixolydian, the full gamut of chromatically altered Mixolydian GS', Lydian b7, Lydian b7 (#9) (only Pass), and altered (only Grasso). None of these GS' feature in Holdsworth's and Monder's pieces because their dominant seventh CT's 'risk' tonicisation.

However, the 'nonfunctional' environments of Holdsworth's and Monder's pieces also facilitate five unique chromatically altered chord scale GS': Dorian (b9), Dorian (#11), Lydian (b9), Lydian (#5), and Lydian (b13). Lydian (#5) was systematised as the example in section '3.11: Chromatically Altered Chord Scale GS''. However, the chord scales of the other four GS' are not systematised by *The Chord Scale Theory & Jazz Harmony* (Nettles and Graf, 1997). This task and the derivation of *g* values is undertaken at the end of this section. Note: CST lists 'Dorian (b2)' (pp. 91) as an option for II-7 in a minor key. The use of 'b2' instead of b9 is presumably to discourage the harmonic use of ANb9.

Finally, whole-tone +7 and whole-tone 7b5 may both be attributed to a single context in Grasso's piece. As will be explained in the following section, the rarity of these GS' is due to their specific requirements. This specificity is shared by symmetric dominant and symmetric diminished – marked by their absence – which will both receive attention in section '4.7: Results'.

***Dorian (b9)*:**

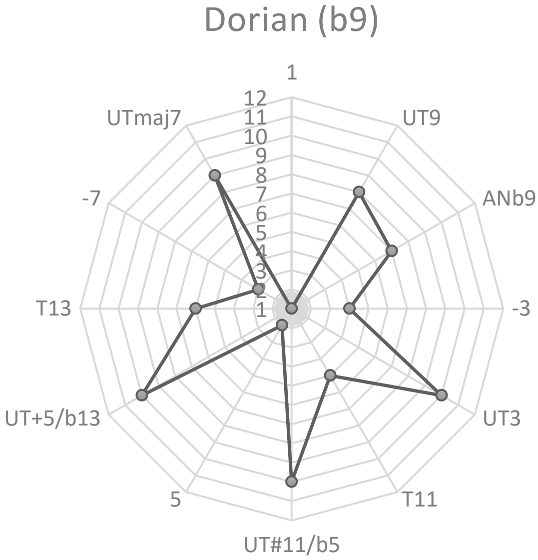
CT configurations analysed: C3, C3+Eb3, C3+G3, C3+Bb3, C3+Eb3+G3, C3+Eb3+G3+Bb3.

- **CT (1, -3, 5, -7):** The same as Dorian.
- **T (T11, T13):** The same as Dorian without T9: T11 = *g*5 and T13 = *g*6.

- **AN (ANb9):** As the lone AN, ANb9 (Db) may be attributed with *g*7. The considerable presence of Db across the spectra of the CT configurations – as identified in the Phrygian analysis – suggests that ANb9 only brings a weak challenge to GSF.
- **UT (UT9, UT3, UT#11/b5, UT+5/b13, UTmaj7):** The Dorian analysis showed that UTb9 (Db) and UTmaj7 (B) were equidistant as the two UT's with the strongest presence. However, UTb9 is replaced in Dorian (b9) with UT9 which has a stronger presence than UTmaj7 across the CT configurations. UTmaj7 only rivals UT9 in the spectra of C3+Eb3, in which they have the same presence. As a result, UT9 assumes *g*8 and UTmaj7 is relegated to *g*9. Like Dorian, UT3, UT#11/b5, and UT+5/b13 share *g*10-*g*12 and all are represented as *g*10.

*g*1	*g*2	*g*3	*g*4	*g*5	*g*6	*g*7	*g*8	*g*9	*g*10		
1	5	-7	-3	T11	T13	ANb9	UT9	UTmaj7	UT3	UT#11/b5	UT+5/b13

Example 4.5b: Dorian (b9) *g* values (table).



Example 4.5b cont.: Dorian (b9) *g* values (radar chart).

***Dorian (#11)*:**

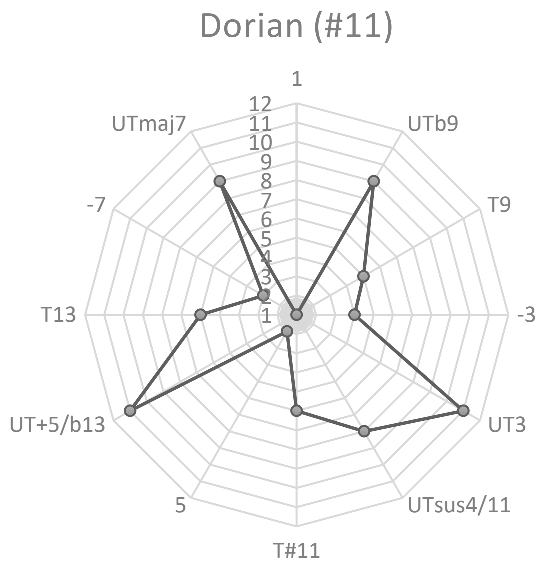
CT configurations analysed: C3, C3+Eb3, C3+G3, C3+Bb3, C3+Eb3+G3, C3+Eb3+G3+Bb3.

- **CT (1, -3, 5, -7):** The same as Dorian.
- **T (T9, T#11, T13):** The T#11 (F#) alteration that replaces Dorian's T11 (F) has comparable presence to T13 (A), which was found to be the most distant Tension in Dorian. F# occurs with WP in the spectra of C3 and C3+Bb3, and NP in the spectra of the minor triad. Similarly, A only occurs with a weak MP in the spectra of C3+Eb3 and WP in the spectra of C3 (and NP after 1000ms). As a result, T#11 and T13 may be judged to jointly occupy *g*6-*g*7 (both represented as *g*6) with T9 as the clear victor (*g*5).

- **UT (UTb9, UT3, UTsus4/11, UT+5/b13, UTmaj7):** The UTsus4/11 (F) that replaces Dorian's UT#11/b5 (F#/Gb) has a stronger presence than UTb9 (Db) and UTmaj7 (B) – the closest of Dorian's UT's – in the spectra of C3+Bb3 and the minor seventh chord. These three gravi-tones share a proximal presence in the spectra of C3+Eb3. Although F's absence in the spectra of the other CT configurations allows 'victories' for the other gravi-tones, F arguably takes the crown due to its strong presence when all CT's are present. The resulting *g* values are: UTsus4/11 = *g*8, UTb9 and UTmaj7 = *g*9-*g*10 (both represented as *g*9), and UT3 and UT+5/b13 = *g*11-*g*12 (both represented as *g*11).

*g*1	*g*2	*g*3	*g*4	*g*5	*g*6		*g*8	*g*9		*g*11	
1	5	-7	-3	T9	T#11	T13	UTsus4/11	UTb9	UTmaj7	UT3	UT+5/b13

Example 4.5c: Dorian (#11) *g* values (table).



Example 4.5c cont.: Dorian (#11) *g* values (radar chart).

***Lydian (b9)*:**

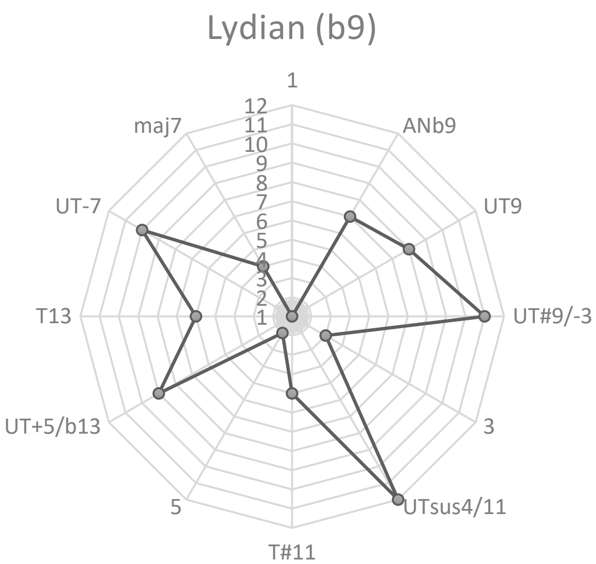
CT configurations analysed: C3, C3+E3, C3+G3, C3+B3, C3+E3+G3, C3+E3+G3+B3.

- **CT (1, 3, 5, maj7):** The same as Lydian.
- **T (T#11, T13):** The same as Lydian without T9: T#11 = *g*5 and T13 = *g*6.
- **AN (ANb9):** As the lone AN, ANb9 (Db) may be attributed with *g*7. Because it only occurs with WP in the spectra of C3+E3, and NP in the spectra of C3 and the major triad, ANb9 may pose a relatively strong challenge to GSF.
- **UT (UT9, UT#9/-3, UTsus4/11, UT+5/b13, UT-7):** The UT9 (D) that replaces Lydian's UTb9 (Db) has the strongest presence of the UT's in the spectra of all CT configurations with G as a present tone. Because this includes the major triad and major seventh chord, UT9 may be regarded as the closest UT and attributed with *g*8.

With adjusted *g* values, the relative distance of the other UT's is identical to Lydian: UT+5/b13 = *g*9, UT-7 = *g*10, UT#9/-3 = *g*11, and UTsus4/11 = *g*12. The result is that Lydian (b9) is the only GS systematised in this thesis with twelve distinct *g* values.

*g*1	*g*2	*g*3	*g*4	*g*5	*g*6	*g*7	*g*8	*g*9	*g*10	*g*11	*g*12
1	5	3	maj7	T#11	T13	ANb9	UT9	UT+5/b13	UT-7	UT#9/-3	UTsus4/11

Example 4.5d: Lydian (b9) *g* values (table).



Example 4.5d cont.: Lydian (b9) *g* values (radar chart).

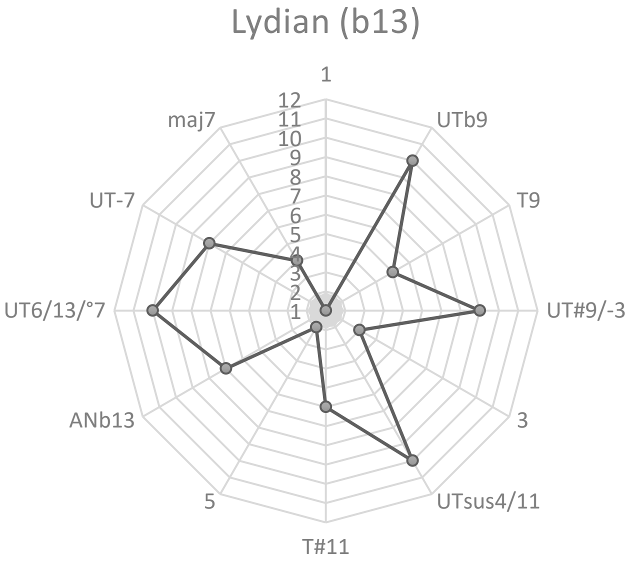
***Lydian (b13)*:**

CT configurations analysed: C3, C3+E3, C3+G3, C3+B3, C3+E3+G3, C3+E3+G3+B3.

- **CT (1, 3, 5, maj7):** The same as Lydian.
- **T (T9, T#11):** The same as Lydian without T13: T9 = *g*5 and T#11 = *g*6.
- **AN (ANb13):** As the lone AN, ANb13 (Ab) may be attributed with *g*7. Ab derives considerable presence as the fifth harmonic of E, occurring with SP in the spectra of C3+E3, and a strong MP in the spectra of the major triad and major seventh chord. As a result, ANb13 may pose a relatively weak challenge to GSF.
- **UT (UTb9, UT#9/-3, UTsus4/11, UT6/13/°7, UT-7):** The UT6/13/°7 (A) that replaces Lydian's UT+5/b13 (G#/Ab) is comparable to the two most distant UT's, UTb9 (Db) and UTsus4/11 (F). Whilst A occurs with WP in the spectra of C3 (and NP after 1000ms), C3+E3, and C3+B3, its absence from the spectra of the major triad and major seventh chord suggests it should be grouped with the most distant UT's. Otherwise, the relative distance of Lydian (b13)'s UT's are equivalent to Lydian's. The resulting *g* values are: UT-7 = *g*8; UT#9/-3 = *g*9; and UTb9, UTsus4/11, and UT6/13/°7 jointly occupy *g*10-*g*12 (all represented as *g*10).

*g*1	*g*2	*g*3	*g*4	*g*5	*g*6	*g*7	*g*8	*g*9	*g*10		
1	5	3	maj7	T9	T#11	ANb13	UT-7	UT#9/-3	UTb9	UTsus4/11	UT6/13/°7

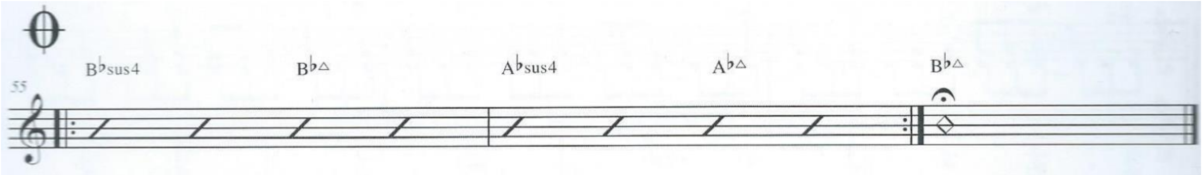
Example 4.5e: Lydian (b13) *g* values (table).



Example 4.5e cont.: Lydian (b13) *g* values (radar chart).

<u>4.6: Gravi-Tone Series Filtering</u>

Ionian: It was argued in section '4.3: Gravi-Tone Series Filtering' that there is increased likelihood of Ionian attribution at beginnings and endings of pieces due to its tonic association. In the selected repertoire of the 'Virtuoso (Pass, 1973b) to Present' era, the opening chords of all pieces may potentially be attributed with Ionian. It is also a candidate for the concluding chords of all pieces except Holdsworth's. Pass and Grasso ensure this with preceding subV7 and V7 chords – a common determinant of Ionian in both pieces – whereas Monder's use is less typical, as shown in Example 4.6a.



Example 4.6a: The coda of Monder's *O.K. Chorale* (1996), demonstrating the attribution of Ionian following suspended chords in the concluding bars of the piece.

Because Bbsus4 bears no established functional relationship with the preceding chords, it is unclear whether it would be attributed with Ionian maj7sus4 or Mixolydian 7sus4. The spectral content of the sus4 triad (C3+F3+G3 in the second table of Example 3.7c) is perceptually impartial: Ionian maj7sus4's B (maj7) is only 1dB louder than Mixolydian 7sus4's Bb (-7). Nevertheless, the context of Monder's piece arguably favours Ionian maj7sus4 through the abundance of Lydian (which shares the maj7 CT) and comparative lack of dominant seventh chords. In this sense, Ionian maj7sus4 may be recognised as a 'contextual alteration' to Lydian.

With the suspension resolved, the subsequent Bbmaj7 chord would be attributed with Ionian. Bar two would be attributed with the same GS': Absus4 bears no functional relationship with Bbmaj7 and would be attributed with Ionian maj7sus4 due to the contextual precedence of the maj7 gravi-tone; Abmaj7 resolves the suspension and would thus be attributed Ionian. On the repeat, it is feasible that Bbsus4 is heard as V7sus4 in Eb major, with the Abmaj7 being retrospectively understood as IVmaj7. However, it seems more likely that the first cycle of the progression is instantiated in the listener's memory as a 'cue' (Deliége and Mélen, 1997, pp. 395), as discussed in section '3.15: Memory and Time (T Axis)'. This would recall the same GS' for the second cycle.

In the final bar, the Bbmaj7 offers similar scope for negotiability. Its ‘nonfunctional’ (Nettles and Graf, 1997, pp. 162) relationship with the preceding chords would seem to suggest Lydian. However, Ionian is arguably favoured due to the GS’ in the preceding bars and the sense of closure. Aside from beginnings and endings, Pass’ and Grasso’ pieces feature other types of Ionian attribution that are unique from ‘The 1930’s and 40’s’ repertoire. Example 4.6b shows the first of these with an extract from Pass’ piece.

Example 4.6b: An extract from Pass’ *Have You Met Miss Jones?* (1973a), demonstrating the attribution of F Ionian to Imaj7 despite the ‘wrong’ cadence.

The Fmaj7 bears no functional relationship with the preceding II-V in Gb major. As a result, F Lydian would appear to be the appropriate option – as identified in the Lydian analysis of section ‘4.3: Gravi-Tone Series Filtering’. However, because the II-V creates expectation for Gb Ionian, Fmaj7 seems to be entreated with the Ionian GS despite an ‘incorrect’ fundamental / *g*1.

It is unlikely that this subverted tonic ‘rule’ extends to all manner of contextual variations e.g., alternate fundamentals, chord structures, cadence types, harmonic rhythms etc. Rather, its potential is perhaps contingent on how evolving listening experience shapes the ‘sonic saddle’ (Shepherd and Wicke, 1997, pp. 174) of each individual. In the case of Example

4.6b, the bar occurs in the B section of *Have You Met Miss Jones?* (Rogers and Hart, 1937) which famously modulates through several keys. Prior to this, however, the A section firmly establishes F major as the key. Therefore, despite the modulations, the resurfacing of F is given further guarantee of Ionian attribution.

Grasso's piece includes two uses of Ionian that are illustrative of how GSF processes basslines. Example 4.6c shows the first of these.

Example 4.6c: An extract from Grasso's *Have You Met Miss Jones?* (TRENIER GUITARS, 2016), demonstrating the attribution of G Ionian and a bassline predicament.

The Gmaj7 chord on beat one is preceded by Ab Lydian b7 / subV7, confirming G Ionian. Because Gmaj7 is the most-populated Y axis structure of the bar with the lowest bass note, it might be argued that G Ionian continues through the rest of the bar. This reading seems acceptable for the structure on beat two e.g., Gmaj7(13)/D (the G, B, and F# are implied from beat one). However, it is also negotiable that D represents a change in the fundamental bass. Because of the G major context, it would be heard as V7 / D7(9) / D Mixolydian.

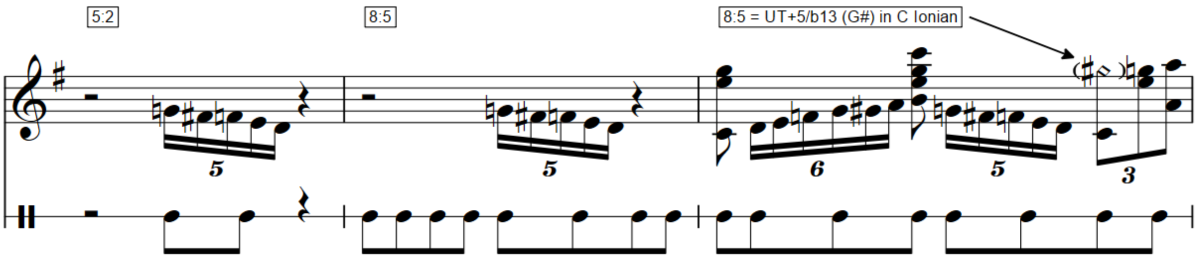
A G Ionian reading of beat three would account for Db as UT#11/b5. However, because its relatively low registral position is uncharacteristic of a UT, it seems significantly more likely to represent a change in GS. Again, because of the G major context, it seems likely that beat three would be attributed with Db Lydian b7 as subV7/IV. This causes the D melody note to be heard as UTb9 (*g*11).

Interestingly, the subV7/IV context seems to negate D's potential to sound closer as a chromatic alteration e.g., Lydian b7 (b9). This may also be a consequence of Lydian b7 only potentially having one common chromatic alteration, as discussed in section '4.3: Gravi-Tone Series Filtering'. Finally, beat four of Example 4.6c represents the resolution from subV7/IV / Db Lydian b7: IV / C Lydian. Example 4.6d shows the second type of 'bassline' that Grasso utilises with Ionian attribution.

Example 4.6d: An extract from Grasso's *Have You Met Miss Jones?* (TRENIER GUITARS, 2016), demonstrating the attribution of C Ionian, a 'bassline' predicament, and arguable influence from the Z axis.

The C major chord at the beginning of the bar would be attributed with Ionian (it is preceded by II-7 to V7 in C major) but the subsequent bassline is less clear. GSF's inherent delay means that the individual tones cannot be processed quickly enough, as discussed in section '3.15: Memory and Time (T Axis)'. The result seems to be that the C Ionian GS continues but the *g* values play less of a role. G# (UT+5/b13 = *g*8), for example, feels barely more distant than the other gravi-tones in the line (if at all). The Cmaj7/B chord reaffirms Ionian, but the *g* values are again weakened in the following line e.g., F# (UT#11/b5 = *g*9) seems no more distant than the neighbouring F (AN11 = *g*7).

Example 4.6d also shows arguable influence from the unified time dimension / Z axis. The quintuplet on beat three forms a 5:2 polyrhythm with the underlying quaver-feel e.g., one beat corresponds to two 'felt' quavers. This ratio – isolated in the first bar of Example 4.6d cont. – does not correspond to any listed in section '3.16: The Unified Time Dimension (Z Axis)'. Instead, as the second bar of Example 4.6d cont. depicts, the quintuplet could be perceptually related to the eight 'felt' quavers of the bar as an 8:5 polyrhythm.



Example 4.6d cont.: Locating the Z axis in Example 4.6d, an extract from Grasso's *Have You Met Miss Jones?* (TRENIER GUITARS, 2016). The 8:5 polyrhythm arguably contributes UT+5/b13 (G#) in C Ionian.

As listed in Example 3.16a of section '3.16: The Unified Time Dimension (Z Axis)', an 8:5 ratio may evoke a +5/b13 gravi-tone. In C Ionian, this would be UT+5/b13 (*g*8) / G#. The third bar of Example 4.6d cont. illustrates how this Z axis contribution may be perceptually built-in to the harmony. It has been included after the quintuplet to allow for recognition of the polyrhythm / interval ratio.

The triplet in the final bar of Example 4.6d may also be considered to represent a 3:2 polyrhythm with the two 'felt' quavers of beat four, corresponding to scale degree 5 (*g*2) in Ionian. Because 5 (G) is already a present tone, a strong partial of the fundamental, and part of Ionian's tonic status gifted by the preceding II-7 to V7, this Z axis contribution merely supports the other qualities. Ionian 3:2 polyrhythms may also be found in Pass' piece as triplets played across two beats. In each case, they simply support GSF's other qualities.

Ionian maj7sus4: Monder's use of this GS was illustrated by Example 4.6a and the accompanying analysis. Its only other use in the selected repertoire is at the beginning of Holdsworth's piece, as shown by Example 4.6e.

Example 4.6e: The opening of Holdsworth's *Looking Glass* (1986), demonstrating the attribution of D Ionian maj7sus4 to the first chord.

As stated in the preceding pages, D Ionian may be attributed to the first chord – despite the presence of AN11 (G) – due to its increased likelihood at the beginning of pieces. However, Ionian maj7sus4 and Mixolydian 7sus4 are perhaps more likely as they position G as sus4, a CT. The chord would be more accurately labelled as Dsus4(9) for each GS. Whilst both are viable, Ionian maj7sus4 seems to have more credibility due to its association with Ionian and its introductory potential.

The two subsequent chords are shown because they illustrate how this attribution changes on the repeat. Because the second chord would be attributed with C Lydian, the first may be retrospectively understood as V7sus4 in G major. This is further supported by the third chord (B Phrygian / III-7 in G major) and the use of A Dorian (II-7) before the repeat. As a result, D Mixolydian 7sus4 would be attributed to the first chord on the second cycle.

It is noteworthy that the present tones of this chord correspond to the same chord scale qualities and *g* values in Ionian maj7sus4 and Mixolydian 7sus4 e.g., D = 1 / *g*1, G = sus4 / *g*2, A = 5 / *g*2, and E = T9 / *g*5. However, as discussed in section '3.12: The Modular Structure of GSF', the *g* values only indicate the relative distance within each GS. The 'absolute' *g* values may vary between the two and result in a different experience.

Dorian: Akin to the previous era, Dorian's attribution in the selected repertoire is to II-7 chords in major keys and minor seventh chords in 'nonfunctional relationships' (Nettles and Graf, 1997, pp. 162). In Pass' and Grasso's pieces, diatonically-related chords are used to prepare and/or retrospectively understand II-7 in a wide variety of keys. Similarly, all minor seventh chords that are 'nonfunctional' with their preceding material are retrospectively understood as II-7 of another key. Both observations are evidenced to a greater extent in Pass' piece.

Unique amongst the selected repertoire of both eras, Pass' and Grasso's pieces feature extended X axis lines that bring memory challenges to GSF through 'modal density' (Vieru, 1993, pp. 50) – as discussed in section '3.15: Memory and Time (T Axis)'. Example 4.6f illustrates this with an extract from Pass' piece.

Example 4.6f: An extract from Pass' *Have You Met Miss Jones?* (1973a), demonstrating the 'nonfunctional' (Nettles and Graf, 1997, pp. 162) attribution of C Dorian and the memory challenges 'modal density' (Vieru, 1993, pp. 50) brings to GSF.

'C11' – more accurately written as C7sus4(9) – would be attributed with Mixolydian 7sus4 as V7sus4 in F major. Despite the subsequent C#'s potential to change the fundamental bass / *g*1 and the GS, C Mixolydian 7sus4 is arguably recovered by the return to C♮. However, due to Mixolydian 7sus4's limited potential for alterations (particularly in comparison to Mixolydian), the following Eb likely changes the GS.

A 'nonfunctional' (Nettles and Graf, 1997, pp. 162) minor third interval may correspond to either Dorian or melodic minor. Dorian seems the likely option for two reasons: (1) in the spectra of C3+Eb3 (see the first table of Example 3.7c), Dorian's Bb (-7) occurs with SP and in two octaves with MP, whereas melodic minor's B (maj7) only occurs with MP; and (2) Dorian may be preferred by the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) due to its significantly more common use. As a result, it may be judged that Dorian is attributed by the Eb in Example 4.3f.

The gravi-tones used on beats three, four, and five include: C (1 / *g*1), Eb (-3 / *g*4), G (5 / *g*2), Bb (-7 / *g*3), and F (T9 / *g*5). This low number of gravi-tones and their close *g* values does not necessarily indicate a strong challenge to GSF's 'power of analysis' (Vieru, 1993, pp. 50). Instead, the passage becomes increasingly open to negotiation through the lack of reference to C / *g*1.

For example, whilst the D at the end of beat three and the subsequent Eb may continue C Dorian, the semitone shift draws attention to Eb. This indicates a potential change to the diatonically-related Eb Lydian (IVmaj7 of Bb major) e.g., C Dorian = II-7 of Bb major. To further sew Eb Lydian's potential, an Eb major arpeggio is completed by the subsequent G and Bb. Pass' Lydian intentions are all but confirmed by the descending Eb major arpeggio on beat five and the constant structures on beat six e.g., D/F = D Lydian, Cb/F = Cb Lydian.

Because Monder's and Holdsworth's pieces do not conform to established functional relationships, their uses of Dorian are generally 'nonfunctional' (Nettles and Graf, 1997, pp. 162). Furthermore, the predominantly 'nonfunctional' environments of these pieces arguably challenge their local-level functionality. Example 4.6g demonstrates this with an extract from Monder's piece.

Example 4.6g: An extract from Monder's *O.K. Chorale* (1996), illustrating how the local-level functionality of F#-7 (III-7 in D Major) may be overridden by its predominantly 'nonfunctional' (Nettles and Graf, 1997, pp. 162) environment.

'G lyd' (Gmaj7(9/#11)) would be attributed with Lydian because the preceding chords do not form an established functional relationship. Because G Lydian may act as IV of D major, F#-7 may be considered functional (III-7) and attributed with Phrygian. Arguably, however, the likelihood of this functional relationship being perceived is reduced by the predominantly 'nonfunctional' nature of the piece. As a result, Dorian may be equally (if not more) viable for F#-7 than Phrygian.

Dorian also receives limited usage as 'II-7' in Monder's and Holdsworth's pieces, despite their avoidance of tonicising major keys. Both pieces prepare II-7 with movement from IVmaj7. For example, Holdsworth's movement from C Lydian to A Dorian may be perceived as IVmaj7 to II-7 in G major. Similarly, II-7 may be retrospectively understood in both pieces. Monder, for example, moves through Bb Dorian (II-7 in Ab major), Ab Ionian maj7sus4 (Imaj7sus4) and Ionian (Imaj7), and Db Lydian (IVmaj7).

As discussed above, such local-level windows of functionality may be challenged by a predominantly 'nonfunctional' environment. However, Dorian's status as the 'nonfunctional' option for minor seventh chords means that its attribution would not be changed. Finally, only Pass engages the Z axis with Dorian. In each case, it is simply a 3:2 polyrhythm (evoking scale degree 5) which merely support GSF's other qualities.

Dorian AN-7: As discussed in the analysis of the previous era, Dorian AN-7 is attributed to Dorian contexts where T13 is present but -7 is not. It is only used in Holdsworth's piece.

Dorian (b9): The attribution of this chromatically altered chord scale GS is negotiable and exclusive to Holdsworth's piece. It would arguably be attributed to the 'Gm7b9' chord in Example 4.6h. The G root is supplied separately by a bass guitar.

Example 4.6h: An extract from Holdsworth's *Looking Glass* (1986), demonstrating the negotiable attribution of G Dorian (b9) to the 'Gm7b9' chord.

From the main GS' systematised in section '3.10: Spectral Analysis: *g* values', only Phrygian can house the 'Gm7b9' without resorting to UT's. However, the consistency of Dorian's attribution across the piece (including the first two chords of the extract) means that it may carry to 'Gm7b9' and accommodate b9: Dorian (b9). This would suggest that 'nonfunctional' (Nettles and Graf, 1997, pp. 162) environments are not only capable of challenging local-level functionality – as discussed in relation to Example 4.6g – but also GS' which may be favoured through their commonality.

In both Phrygian and Dorian (b9), the G# in Example 4.6h represents ANb9. This means the chord would be written as G-7(11/<u>b9</u>). Because Dorian (b9)'s ANb9 is more distant (*g*7) than Phrygian's (*g*6), the former seems to better reflect the distance felt in Example 4.6h. In addition, this GS may be considered as the second mode of melodic minor.

Dorian (#11): Like Dorian (b9), Dorian (#11) is negotiable and exclusive to Holdsworth's piece. It would arguably be attributed to the 'Gm7#11' chord in Example 4.6i.

Example 4.6i: An extract from Holdsworth's *Looking Glass* (1986), demonstrating the negotiable attribution of G Dorian (#11) to the 'Gm7#11' chord.

The 'Fm7#5' may be perceived as III-7 of Db major (Phrygian) because it is preceded by Gb Lydian. However, Aeolian is also possible if the local-level functionality is negated by the 'nonfunctional' environment. In either case, 'Fm7#5' would be better described as F-7(b<u>13</u>) because it contains ♮5 (C). The following F#-7 would be attributed with Dorian because it is 'nonfunctional'. Despite the Phrygian / Aeolian interruption, the consistent use of Dorian potentially carries to 'Gm7#11' and accommodates the #11 – as argued with Dorian (b9).

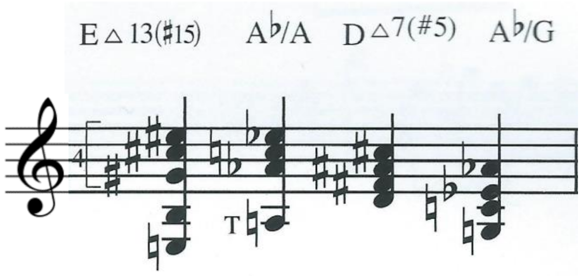
None of the main GS' systematised in section '3.10: Spectral Analysis: *g* values' can house this structure without resorting to UT's. As a result, it would be attributed with Dorian (#11) and labelled as G-7(#11). This GS may also be considered as the fourth mode of the harmonic minor scale.

Phrygian: This GS occurs as the III-7 of a major key in all four pieces. Whilst common in Pass' piece and (to a lesser extent) Grasso's, it is arguably negated by the challenge to local-level functionality in Monder's and Holdsworth's pieces – as discussed in relation to Example 4.6g. Nevertheless, there are windows where functionality arguably shines through. Example 4.6i demonstrates this with an extract from Monder's piece.

Example 4.6j: An extract from Monder's *O.K. Chorale* (1996), demonstrating increased likelihood of recognising III-7 through transposed repetition.

As discussed in relation to Example 4.6g, the chances of recognising Gmaj7(13/9/#11) to F#- as IVmaj7 to III-7 in D major are reduced by the 'nonfunctional' environment. This would result in F# Dorian instead of Phrygian. Because Fmaj7(13) and E-7(11) may also represent IVmaj7 and III-7 (in C major), the 'repetition' arguably increases the likelihood of E-7(11) being attributed with Phrygian. This may also involve a retrospective understanding of F#- as III-7 / Phrygian.

However, it may also be that G Lydian to F# Dorian is instantiated in the listener's memory as a 'cue' (Deliége and Mélen, 1997, pp. 395) – as discussed in section '3.15: Memory and Time (T Axis)' – that may recall the same GS' for Fmaj7(13) and E-7(11). Phrygian is also a potential option for 'nonfunctional' (Nettles and Graf, 1997, pp. 162) minor seventh chords with b9, as illustrated by Example 4.6h and the accompanying analysis. The 'Ab/G' in Example 4.6k (an extract from Monder's piece) represents a similarly negotiable attribution.



Example 4.6k: An extract from Monder's *O.K. Chorale* (1996), demonstrating the negotiable attribution of Phrygian to 'Ab/G'.

This chord shares no functional relationship with those preceding it. If Ab is heard as the fundamental / *g*1 (as the symbol suggests), then the structure would be understood as a major seventh chord in third inversion (maj7 as lowest gravi-tone) and attributed with Lydian. However, as the lowest note, G is also a viable option as *g*1. This would result in the following intervals: C = sus4/11, Eb = +5/b13, and Ab = b9.

Of the main GS' systematised in section '3.10: Spectral Analysis: *g* values', only Locrian and Phrygian would be options. Phrygian may arguably be favoured by the strength of the third harmonic (D = scale degree 5) in the series of the fundamental (G). C is also a candidate for *g*1 due to the second inversion minor triad formed by the lowest three tones of 'Ab/G'. The additional Ab represents b13 which is indicative of Phrygian and Aeolian. In this case, Aeolian would arguably be the victor as its greater role in the tonal system may condition the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) to expect it.

Finally, like Dorian, only Pass engages the Z axis with Phrygian. It occurs once with a 3:2 polyrhythm (evoking scale degree 5) that merely support GSF's other qualities.

Lydian: Lydian may be attributed to the selected repertoire via the same three routes as that of the previous era. Firstly, in addition to Ionian, the opening chords of all pieces except Holdsworth's may also correspond to Lydian. Of the three, Pass' is the most likely because it contains a maj7 present tone that boosts the Lydian T#11 in the spectra – as observed in section '3.9: Spectral Analysis: GSF for Tempered PT Combinations'.

Secondly, Lydian receives notably limited usage as IVmaj7 in a major key. This is perhaps surprising given that its subdominant cousin, II-7, occurs so frequently. In Pass' piece, IVmaj7 only occurs once as a chord and several times (perhaps unintentionally) on the X axis through the memory implications of 'modal density' (Vieru, 1993, pp. 50) – as demonstrated by Example 4.6f and the accompanying analysis.

Similarly, IVmaj7 surfaces once in Grasso's piece as a chord, and several times via basslines – as illustrated by Example 4.6c and the accompanying analysis. In Holdsworth's and Monder's pieces, it is far more common for IVmaj7 to be retrospectively understood than prepared. Rather, its initial attribution is almost always 'nonfunctional' (Nettles and Graf, 1997, pp. 162) – the third route of attribution. Pass only elects this route twice and it is not taken by Grasso.

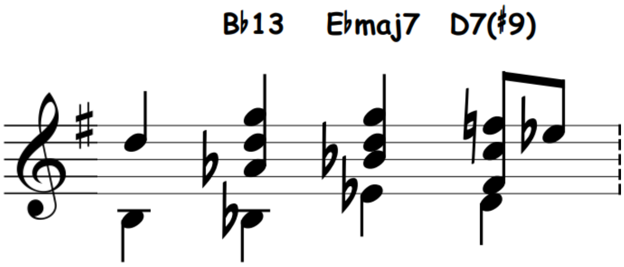
Lydian (b9): Like Holdsworth's use and alteration of Dorian, Monder's consistent use of Lydian in a 'nonfunctional' environment potentially results in three chromatically altered forms. The first of these is evidenced by the first chord in Example 4.6k. Preceded by Gbmaj7(#11), the Lydian sound is carried to this chord and accommodates b9 (E#): E Lydian (b9). The chord may be more accurately labelled as Emaj7(13/<u>b9</u>). Because ANb9 (*g*7) sounds distant, it may be confused with UTb9 (*g*11) of Lydian. However, Lydian attribution would require a present T9 (F#) to prevent itself being usurped by ANb9.

Lydian (#5): The second chromatically altered form of Lydian is arguably demonstrated by the third chord in Example 4.6k. As with Lydian (b9), the consistent use of Lydian carries to this chord and accommodates +5 (A#): Lydian (#5). Because A# is in close position with the fundamental (D), it overcomes the presence of A (scale degree 5) as a partial. In doing so, A# arguably stakes its claim as a replacement CT (+5 / *g*2) instead of being subordinated as ANb13 (*g*7). Therefore, the chord may be more accurately labelled as D+maj7.

Lydian (b13): The third and final chromatically altered form of Lydian is demonstrated by the second chord in Example 4.6g. Unlike the D+maj7 chord in Example 4.6k, the chord in Example 4.6g positions the +5/b13 gravi-tone (F#) over an octave above the fundamental (Bb). This arguably allows the third harmonic (F) of the fundamental to retain its status as a CT (5 / *g*2), thus subordinating F# to ANb13 (*g*7). Therefore, the chord may be more accurately labelled as Bbmaj7(b13).

Mixolydian: As discussed for the previous era, Mixolydian can be attributed to unaltered seventh chords as primary, secondary (V7/IV and V7/V), and sequential dominants. All three types of attribution are evidenced in Pass' piece, although V7/IV does not occur – perhaps unsurprising given IVmaj7's minimal usage. Grasso, on the other hand, only uses the primary dominant without alterations. Dominant seventh chords in general are not used in Holdsworth's and Monder's pieces. Combined with the minimal use of Ionian, this is presumably to maintain their 'nonfunctional' (Nettles and Graf, 1997, pp. 162) environments by avoiding the 'risk' of tonicisation, Finally, as observed for Ionian, Dorian, and Phrygian, Pass engages the Z axis for Mixolydian by using 3:2 polyrhythms (evoking scale degree 5) that merely support GSF's other qualities.

Mixolydian (#9): Pass uses Mixolydian (#9) once as the primary dominant (Eb7(#9) = V7 in Ab major) and three times with D7(#9) in sequential dominant progressions. Grasso's single use is more negotiable, as shown in Example 4.6l.



Example 4.6l: The penultimate bar of Grasso's *Have You Met Miss Jones?* (TRENIER GUITARS, 2016), demonstrating the negotiable attribution of Mixolydian (#9) to D7(#9).

With reference to the preceding chords, D7(#9) may be perceived as V7/III (Mixolydian (b9, #9, b13) in Eb major. Alternatively, as the penultimate bar of a piece with the prevailing key is G major, D7(#9) may also be recognised as V7. With the #9 alteration, this would result in Mixolydian (#9). Despite this, the GS would be converted to Mixolydian (b9, #9, b13) by the subsequent Eb (b9) that also brings Ab (b13) from the spectra – as shown by the altered ladder of fifths (Example 4.2b).

Mixolydian (b13): Two of the three attribution methods outlined in the Mixolydian (b13) analysis of the previous era can be found in Pass' and Grasso's pieces. Firstly, Pass makes a single use of an unaltered V7/II chord for which Mixolydian (b13) is the diatonically-appropriate GS. Secondly, both pieces use 7(9/b13) chords. As discussed earlier, ♮9 negates the #9 that b13 can bring from the altered ladder of fifths (Example 4.2b) – resulting in Mixolydian (b13).

Mixolydian (b9, #9): As discussed in the analysis of the previous era, Mixolydian (b9, #9) may arguably be attributed to dominant seventh chords where both b9 and ♮13 are present. It was explained that the listener's learned association between b9 and #9 in the altered ladder of fifths (Example 4.2b) may overcome the 'broken rung' (b13). Mixolydian (b9, #9) occurs seven times in Pass' piece and once in Grasso's. All examples are Y axis structures with no X axis elaboration.

Mixolydian (#9, b13): Of the four attribution methods outlined in the previous era, only the first is used in Pass' and Grasso's pieces: Mixolydian contexts where ♮9 is not a present tone but b13 as an altered present tone brings #9 from the spectra, as shown by the altered ladder of fifths (Example 4.2b). There are four examples of this in Pass' piece and two in Grasso's. Mixolydian (#9, b13)'s limited use mirrors the previous era and further explains why it goes unmentioned in CST (Nettles and Graf, 1997).

Mixolydian (b9, #9, b13): As discussed in the analysis of the previous era, Mixolydian (b9, #9, b13) may be attributed as a diatonically-appropriate GS or by evoking the altered ladder of fifths (Example 4.2b) with a b9 alteration. Diatonically-appropriate applications may be identified in Pass' and Grasso's pieces as V7/VI, Pass' as V7/III, and Grasso's as V7(b9) in a minor key. Whilst most of these attributions are clear-cut, Pass' piece includes a common chord progression (Example 4.6m) that demonstrates how V7/VI may be negotiable.

Example 4.6m: An extract from Pass' *Have You Met Miss Jones?* (1973a), demonstrating the negotiable attribution of Mixolydian (b9, #9, b13) as the diatonically-appropriate GS for A7(b13) (V7/VI).

The A7(b13) may be heard as V7/VI because of the F major context. This is supported by its resolution to III-7 (D-7). However, because 'Em7' (better labelled as E-7b5 to reflect Locrian / VII-7b5 function, despite the absent b5) and A7(b13) also represent II-7b5 to V7 in D Minor, A7(b13) may be attributed with Mixolydian (b13) – as listed in section 'A.4: Minor Key Harmony'.

The 'risk' of Mixolydian (b13) is arguably stronger when a major key is less well-established. Because there are no modulations prior to Example 4.6m, Mixolydian (b9, #9, b13) may be more likely. In any case, the present tones of A7(b13) have identical *g* values in each GS. Example 4.6n is an extract from Grasso's piece that illustrates the attribution of Eb Mixolydian (b9, #9, b13) as the diatonically-appropriate GS for V7(b9) with two intriguing characteristics.

Example 4.6n: An extract from Grasso's *Have You Met Miss Jones?* (TRENIER GUITARS, 2016), demonstrating the attribution of E Mixolydian (b9, #9, b13) as the diatonically-appropriate GS for V7(b9) in Ab Minor.

Firstly, 'modal density' (Vieru, 1993, pp. 50) poses minimal risk to Mixolydian (b9, #9, b13)'s attribution despite the X axis orientation of the line. This is because the seven present tones (Eb = 1, Fb = Tb9, G = 3, Ab = AN11, Bb = 5, Cb = Tb13, and Db = -7) are mostly repeated and played rapidly over the short duration of two beats.

Secondly, the Z axis is arguably triggered by an 8:5 ratio (emphasising Tb13) between the demisemiquavers and the five beats in the bar. This would be the reverse of Example 4.6d, in which the 8:5 ratio was formed by a quintuplet and an underlying quaver-feel. Because forty demisemiquavers and ten quavers are required to fill a 5/4 bar, Example 4.6n technically shows a 40:10 / 4:1 ratio. Nevertheless, like Example 4.6d, a perceptual linkage should not be ruled out.

Pass uses the altered ladder of fifths (Example 4.2b) five times to use Mixolydian (b9, #9, b13). In each case (all V7 chords except one V7/II), Pass demonstrates an intuitive awareness for the ladder by only using the b9 alteration. Contrastingly, Grasso uses the ladder twice and couples b9 with b13 in one of these occurrences. Only Pass uses the Z axis alongside Mixolydian (b9, #9, b13)'s attribution via the ladder, with a single 3:2 polyrhythm (evoking scale degree 5) that simply supports GSF's other qualities.

Mixolydian 7sus4: This GS occurs in all pieces except Grasso's. Its negotiable presence in Holdsworth's and Monder's pieces has already been identified in Example 4.6e and Example 4.6a, respectively. Monder's piece also features a less negotiable use in the solos section with a B7sus4(9) chord that bears no functional relationship with the preceding chords.

Contrastingly, all four of Pass' uses are implicated in functional relationships: two follow perfect cadences, one follows a sequential substitute chord (see section 'A.2.5: Sequential Substitute'), and the other follows V7 as V7sus4. The occurrence following the sequential substitute engages the Z axis with another 3:2 polyrhythm (evoking scale degree 5) that simply supports GSF's other qualities.

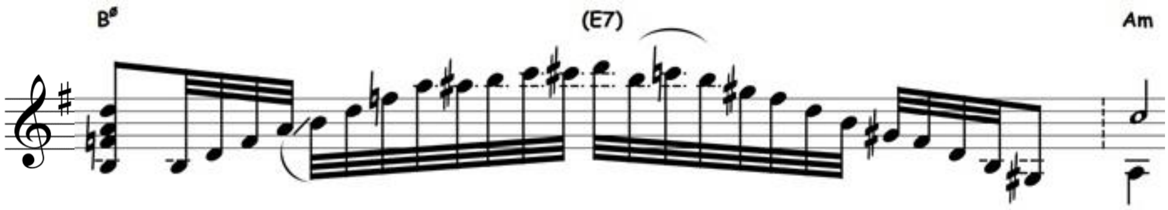
Aeolian: Aeolian's minimal presence in Holdsworth's and Monder's pieces is presumably to maintain their 'nonfunctional' (Nettles and Graf, 1997, pp. 162) environments by preventing tonicisation. Similar to Ionian, however, Aeolian manages to surface in negotiable circumstances. Whilst it is never prepared through local-level functionality (like Phrygian), it may be an option for specific present tone combinations. This has been illustrated by Example 4.6i (Holdsworth), Example 4.6k (Monder), and their accompanying analysis.

In Pass' and Grasso's pieces, on the other hand, Aeolian is implicated as a function of tonality. The D-7 chord in Example 4.6m may arguably assume either role, depending on whether A7(b13) is perceived as V7/VI or V7 of a minor key. Pass repeats this pattern of GS' a further five times. In one such instance, Aeolian is arguably carried through constant structure (see section 'A.8.2: Constant Structures) – as demonstrated by Example 4.6o.

Example 4.6o: An extract from Pass' *Have You Met Miss Jones?* (1973a), demonstrating the negotiable attribution of Aeolian through constant structure.

Whether D-7 is attributed with Aeolian as VI-7 of major or a minor tonic, this functional identity may be carried to C#-7 and C-7 through constant structure. The C Aeolian passage is then retrospectively understood as C Dorian / II-7 of Bb major with the change to F7(13) / V7 and Bb(13/9) / Imaj7. Alternatively, if the listener perceives C#-7 as 'nonfunctional', then itself and C-7 may directly be attributed with Dorian.

Unlike Pass, Grasso never uses Aeolian as VI-7. Instead, there are four similar minor key cadences that may be completed by A Aeolian as the tonic (I-7). Example 4.6p shows one of these cadences.



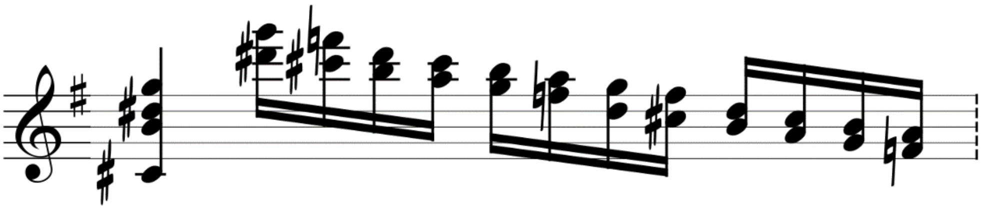
Example 4.6p: An extract from Grasso's *Have You Met Miss Jones?* (TRENIER GUITARS, 2016), demonstrating the negotiable attribution of A Aeolian as the tonic (I-7) of A Minor.

In isolation, this progression would clearly be attributed with the corresponding GS' of the minor key: B-7b5 / II-7b5 / B Locrian, E7 / V7 / E Mixolydian (b13), and A- / I-7 / A Aeolian. However, all such cadences in Grasso's piece are preceded by and exist within a predominantly G major environment. Not unlike the F major context of Example 4.6m influencing the perception of D-7 as VI-7, it may be that G major environment of Grasso's piece challenges the A Minor cadence. Whilst B-7b5 may still correspond to Locrian, E7 and A- may respectively be perceived as V7/II (Mixolydian b13) and II-7 (Dorian).

Locrian: This GS is another casualty of Holdsworth's and Monder's 'nonfunctional' environments. Whilst it is an unlikely option for a single chord in Monder's piece (as argued in relation to Example 4.6k), neither guitarist supplies a -7b5 chord or appropriate local-level functionality. Interestingly, Pass and Grasso only satisfy one of these criteria each. Pass' use of Locrian is always prepared as VII-7b5 (as demonstrated by Example 4.6m and Example 4.6o) but leaves the b5 CT implied – presumably an aesthetic choice. In contrast, Grasso's use is always 'nonfunctional' with the preceding harmonies but ensures Locrian attribution through the presence of all -7b5 CT's.

Lydian b7: Although absent from Holdsworth's and Monder's piece due to the lack of dominant seventh chords, Lydian b7 is a regular feature of Pass' and Grasso's pieces. Pass' usage occurs through three types of substitute dominant chords (subV7, subV7/II, and sub V7/III – as described in section 'A.2.4: Substitute'), sequential substitute progressions (demonstrated earlier with Example 4.3v – also described in section 'A.2.5: Sequential Substitute'), and occasional 'nonfunctional' dominant seventh chords.

Whilst Grasso's use is limited to subV7 chords and 'nonfunctional' harmonies, two examples stand out. Firstly, a well-defined subV7/IV and a fundamental / *g*1 sufficiently enables UTb9 (*g*11) – as illustrated by Example 4.6c and the accompanying analysis. The second is illustrated by Example 4.6q.



Example 4.6q: An extract from Grasso's *Have You Met Miss Jones?* (TRENIER GUITARS, 2016), demonstrating an intriguing transition from C# Lydian b7 into a GS based on the whole-tone scale.

The bar begins with a C#7(9/#11) chord which may be perceived as 'nonfunctional' with or as subV7/IV of the preceding G major environment. In either case, it would be attributed with Lydian b7. C#7(9/#11) is followed by a descending whole-tone scale harmonised in major thirds. Whilst this indicates a change from Lydian b7, the point of transition and the new GS are far from clear.

The first three thirds are all shared with Lydian b7's chord scale (i.e., its CT's and T's) – C# (1), D# (T9), F (3), G (T#11), B (-7) – but the fourth contains A / UT+5/b13 (*g*8). It may be that A (and its repeated use) is simply perceived as a UT with the other gravi-tones bringing assuredness to GSF's attribution of Lydian b7.

However, if not the first time, A's repeated use may increasingly 'risk' a change in GS. For two reasons, the new GS may be derived from the whole-tone scale. Firstly, A's presence completes a whole-tone scale in combination with the aforementioned notes. Secondly, because the movement through whole tones and parallel major thirds are highly typical of whole-tone contexts, the listener's 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) may have been shaped to expect a whole-tone GS.

Three GS' based on the whole-tone scale have been identified in this research: whole-tone +7, whole tone 7b5, and altered (♮9). The latter may be ruled out for Example 4.6q as there is no expectation to resolve down a perfect 5th – as discussed in the altered (♮9) analysis of the previous era. Of the two remaining options, it may be reasoned that whole-tone +7 is favoured because it shares T#11 with Lydian b7.

However, given that whole-tone passages are rare compared to other GS' (this is the only example across the selected repertoire of both eras), the 'sonic saddle' may ensure that whole-tone 7b5 remains an option for listeners with greater experience of it. Whether whole-tone +7 or whole-tone 7b5 is attributed, the fundamental / *g*1 is a further problem. The symmetry of the whole-tone scale means that any component tone may represent the root of a whole-tone GS, as discussed regarding Olivier Messiaen's first mode (1956) in section '3.14: GS Subsets and 'Exotic' Scales'.

The lack of low register tones following C#7(9/#11) chord suggests that its fundamental is shared with the whole-tone GS. Arguably, however, A is also a potential fundamental given its central role in undermining Lydian b7. A's significance may also allow it to direct an alternative fundamental or GS in which it has a lower / closer *g* value. For example, it may bring F as an option for *g*1 because it represents scale degree 3 (*g*2) in both whole-tone +7 and whole-tone 7b5. It is also possible that GSF's inherent delay combined with the rapidity of the passage prevents *g*1 from being determined.

Example 4.6q cont. illustrates this array of GS' with their discussed fundamentals / *g*1's. This comparative representation of the mappings of pitch classes to gravi-tones / *g* values emphasises Example 4.6q's potential for experiential diversity. Whilst there are observable consistencies (e.g., E#/F and C# are CT's in all but one GS each), the signature mapping of each GS and corresponding fundamental ultimately offers a discrete experience.

Lydian b7												
***g* values**	*g*1	*g*2			*g*5	*g*6		*g*8			*g*11	
gravi-tones	1	3	5	-7	T9	T#11	T13	UTsus4/11	UT+5/b13	UTmaj7	UTb9	UT#9/-3
C# as *g*1	C#	E#	G#	B	D#	G	A#	F#	A	C	D	E

whole-tone +7												
***g* values**	*g*1	*g*2			*g*5		*g*7	*g*8			*g*11	
gravi-tones	1	3	+5	-7	T9	T#11	UT5	UT#9/-3	UTsus4/11	UTmaj7	UTb9	UT6/13/°7
C# as *g*1	C#	E#	A	B	D#	G	G#	E	F#	C	D	A#
A as *g*1	A	C#	E#	G	B	D#	E	C	D	G#	Bb	F#
F as *g*1	F	A	C#	Eb	G	B	C	G#/Ab	A#/Bb	E	Gb	D

whole-tone 7b5											
***g* values**	*g*1	*g*2			*g*5	*g*6	*g*7	*g*8			*g*11
gravi-tones	1	3	b5	-7	Tb13	T9	UT5	UTb9	UTsus4/11	UTmaj7	UT6/13/°7
C# as *g*1	C#	E#	G	B	A	D#	G#	D	F#	C	A#
A as *g*1	A	C#	Eb	G	F	B	E	Bb	D	G#	F#
F as *g*1	F	A	Cb	Eb	Db	G	C	Gb	A#/Bb	E	D

Example 4.6q cont.: The range of GS' and their fundamentals / *g*1's that may be attributed to Example 4.6q, an extract from Grasso's *Have You Met Miss Jones?* (TRENIER GUITARS, 2016).

As a final note on Lydian b7, Pass and Grasso both use 3:2 polyrhythms (evoking scale degree 5) that simply support GSF's other qualities.

Lydian b7 (#9): As discussed in the Lydian b7 (#9) analysis of section '4.3: Gravi-Tone Series Filtering', this GS is attributed to Lydian b7 contexts (i.e., dominant seventh chords with no expectation to resolve down a perfect 5^{th}) with a #9 alteration as a present tone. Across the selected repertoire, it only occurs three times in Pass' piece.

altered: As discussed in the altered analysis of section '4.3: Gravi-Tone Series Filtering', this GS is attributed to dominant seventh chords expected to resolve down a perfect 5^{th} with a b5 alteration and no unaltered Tensions. Across the selected repertoire, it only occurs three times in Grasso's piece.

melodic minor: In the melodic minor analysis of section '4.3: Gravi-Tone Series Filtering', it was argued that this GS is a more likely candidate for minor major seventh chords (-maj7) than harmonic minor. In the selected repertoire, melodic minor may be attributed once apiece to Pass' and Grasso's pieces. Both feature -maj7(9) chords that act as an auxiliary to II-7 with the same fundamental. Pass, for example, uses a G-maj7(9) which is preceded and followed by G-7 as II-7 of F major.

whole-tone +7: The lone (negotiable) use of this GS in the selected repertoire was illustrated by Example 4.6q and the accompanying analysis.

whole-tone 7b5: As above.

Summary: Not unlike the 'The 1930's and 40's' repertoire, the analysis of the '*Virtuoso* (Pass, 1973b) to Present' era tended to be dominated by GSF's first (present tones) and third (memory traces of preceding tones) qualities due to the significant influence of functional relationships. Also mirroring the first era, GSF's second quality (harmonic spectra) was shown to have sporadic influence for: chords at the beginning of pieces (as demonstrated by Monder's piece in Example 4.6a), the attribution of Lydian to 'nonfunctional' (Nettles and Graf, 1997, pp. 162) major seventh chords, and the altered ladder of fifths (as shown in Example 4.2b).

Additionally, however, the influence of GSF's second quality was increased by the 'nonfunctional relationships' in Monder's piece. This was evidenced in Example 4.6k by Phrygian's arguable victory over Locrian and the discrepancy between Lydian (#5) and Lydian (b13). Although Holdsworth's piece is similarly 'nonfunctional', the same process was not evident due to the specificity of present tones e.g., the attribution of Dorian (b9) and Dorian (#11) did not need to defer to harmonic spectra.

This era also evidences increased use of the unified time dimension (Z axis – GSF's fourth quality), although it is only a factor in Pass' and Grasso's pieces. Whereas Pass only uses 3:2 polyrhythms to evoke scale degree 5 in GS' that already contain it as a CT (thus having no bearing on GSF), Grasso's 8:5 polyrhythms evoke UT+5/b13 (*g*8) in Ionian and Tb13 (*g*5) in Mixolydian (b9, #9, b13). The former contributes an additional gravi-tone to the context, albeit in a way that brings no challenge to GSF's other qualities.

Finally, the ways in which the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) may be shaped for the 'Western listener' identified in the first era's repertoire have been equally applicable to the second e.g., Ionian and Aeolian for tonic major and minor chords, the altered ladder of fifths etc. Additionally, however, the second era has pointed towards three further ways: a subverted tonic 'rule' where Ionian may still be attributed to an incorrect fundamental (discussed in relation to Example 4.6b); the potential attribution of Dorian to ‘nonfunctional’ (Nettles and Graf, 1997, pp. 162) minor third intervals (Example 4.6f); and how movement through whole-tones and parallel third intervals may result in the attribution of a whole-tone GS (Example 4.6q).

4.7: Results

This Chapter’s analysis of the chord-melody jazz guitar repertoire has uncovered further details of the ‘neutral level’ (Nattiez, 1990, pp. 12) and full models of Gravitonicity. Forty-three notated examples (and hundreds more summarised in-text) have been provided as evidence for how GS’ construct the functional relationships of tonality, modality, blues, and so-called ‘nonfunctional relationships’ (Nettles and Graf, 1997, pp. 162).

From these examples, seventeen additional GS’ have been identified for a total of thirty-two. The potential number of GS’ is practically limitless when accounting for chromatic alterations and alternate chord scale formulations. However, whilst some of the newly-identified GS’ may only be attributed to specific contexts (e.g., the chromatically altered forms of Dorian and Lydian), many have proven as fundamental to Western harmony as the original fifteen. Those corresponding to altered dominant seventh chords, for example, play an unquestionably significant role in jazz harmony.

Of the original fifteen, two GS’ have been conspicuous by their absence: symmetric dominant and symmetric diminished. As included in the Appendix, Nettles and Graf (1997) write that symmetric dominant is ‘an alternative for the Mixolydian and the Lydian b7 scales' (pp. 59) (section ‘A.2.4: Substitute’), an option for blue note rooted seventh chords (section ‘A.3.1: Special Function Blues Chords’), VII7 (section ‘A.3.2: Special Functions for Secondary Dominants’), ‘worth investigating for potential usage' (pp. 107) with dominant seventh chords in a blues (section ‘A.5: Blues Chord Scales’), and ‘a particularly good scale choice for *symmetric* nonfunctional *dominant* chords' (pp. 168) (section 'A.8.1: Contiguous Dominants').

Despite the seemingly varied potentials of this GS, Nettles and Graf caveat its use by stating that it depends 'on the choice of the player/writer and circumstances' (pp. 123). This is because symmetric dominant features an internal conflict: 'The lower half is altered (b9, #9); the top half is Lydian b7 (#11, 13)' (pp. 93). It was discussed in the Lydian b7 analysis of the first era how chords expected to resolve down a perfect fifth use Mixolydian or a chromatically altered form (including altered) whereas those that are not use Lydian b7.

The internal conflict of symmetric dominant means that it does not neatly align with either category: no form of Mixolydian contains T#11 and no identified form of Lydian b7 contains b9. The rarity of contexts that feature both characteristics is evidenced by their absence from the selected chord-melody jazz guitar repertoire, particularly as it features many altered dominant seventh chords. This emphasises that symmetric dominant's use is a conscious 'choice of the player/writer' (pp. 123).

Symmetric diminished also features something of an internal conflict. As discussed at the beginning of this Chapter, GS' based on diminished seventh chords (except for symmetric diminished) were omitted from the analysis. This was due to the sheer variety of GS' that may arise from how diminished seventh chords may be functioning with respect to a key and perhaps other functional relationships. Whereas the Tensions of these GS' 'should be diatonic' (pp. 114), those of symmetric diminished do not indicate any recognisable key. It is therefore an appropriate GS 'for use when the diminished 7th chord is *not* functioning diatonically'. No such diminished seventh chords were identifiable in the selected repertoire.

Although absent from the selected chord-melody jazz guitar repertoire, an online search reveals many examples of the symmetric dominant and symmetric diminished GS' in classical and jazz music. For example, in their guise as whole-half and half-whole octatonic scales, scholars have identified their use in the works of Igor Stravinsky (e.g., Tymoczko, 2002) and Chick Corea (Strunk, 2016). Similarly, section '3.14: GS Subsets and 'Exotic' Scales' illustrated how both GS' can be derived from the second of Olivier Messiaen's 'Modes of Limited Transpositions' (1956, pp. 58).

GSF's attribution of the thirty-two GS' – minus symmetric dominant and symmetric diminished – has been from an interplay of its four qualities: (1) the present tone(s), (2) their harmonic spectra, (3) memory traces of preceding tones, and (4) the unified time dimension (Z axis). Whilst each quality may have received more attention than the others at various points of the analysis, they were never acting independently of each other. This is perhaps unsurprising given that GSF may be initiated by a single present tone (first quality) with its natural spectra (second) from which memory traces (third) and the Z axis (fourth) are potential extensions.

In terms of their respective influence on GSF, however, the four qualities are seemingly never balanced. Present tones played an integral role throughout the analysis, as might be expected. In stark contrast, the Z axis played a minimal role in the first era and, in the second, was only a factor in Pass' and Grasso's pieces. In Pass' piece and those of the first era, the 3:2 polyrhythms in GS' containing scale degree 5 as a CT merely supported GSF's other qualities i.e., 5 as a present tone or harmonic of the fundamental.

Grasso's 8:5 polyrhythms evoke UT+5/b13 (*g*8) in Ionian and Tb13 (*g*5) in Mixolydian (b9, #9, b13). The former is the only example across the repertoire in which the Z axis contributes an additional gravi-tone. However, considering that Ionian would still be attributed by GSF's other qualities, this contribution amounts to little more than colouration. It is feasible that the limited role of GSF's fourth quality reflects its minimal (or lack of) influence. Alternatively, its specificity of application may escape creative intuition and require conscious knowledge from the practitioner. If the latter is the case, then this research may play a part in bringing awareness to the Z axis and ensuring its presence in music of the future. This may include the chord-melody jazz guitar repertoire.

The relative influence of GSF's second and third qualities are curiously inter-related. Although the second has principally assisted with the *g* values of each GS, the analysis illustrated that harmonic spectra can also play a role in GS attribution. This was most prevalent for chords at the beginning of pieces and for the attribution of Lydian to 'nonfunctional' (Nettles and Graf, 1997, pp. 162) major seventh chords.

When GSF's third quality enters the fray, however, the influence of harmonic spectra is greatly tempered. For example, as identified in section '3.9: GSF for Tempered PT Combinations', the spectra of a major seventh chord corresponds more closely with Lydian than Ionian. Nevertheless, if memory traces of preceding tones cast the chord as tonic / Imaj7, then it will unequivocally be attributed with Ionian.

This tempering effect was covertly in play throughout the analysis, as evidenced by the general focus on how present tones and memory can lead to functional relationships. Despite this, the influence of spectral content has been proven to persist in functional relationships through the altered ladder of fifths. Further potentials of GSF's second quality should not be ruled out, therefore. In order of most to least, the following shows the relative influence of GSF's four qualities (for this analysis, at least): present tone(s), memory traces of preceding tones, harmonic spectra, the unified time dimension (Z axis).

Beyond the 'neutral level' (Nattiez, 1990, pp. 12), the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) acts as GSF's omni-present 'fifth quality': the ultimate arbiter of GSF. No matter the complexity of 'neutral level' (Nattiez, 1990, pp. 12) negotiation, GSF will process an output using the individual's evolving listening experience of the GS modules and long-term mental representations of: (1) inputs to the GSF module that are attributed with a single GS, and (2) patterns of multiple GS'.

This goes for the many analytical examples that were seemingly beyond the gaze of 'neutral level' (Nattiez, 1990, pp. 12) inquiry. Moreover, the experience of Gravitonicity may be further individualised by our physical perception, mapping GS' onto physical schemas (e.g., the Sagrada Familia consideration relating to Reinhardt's use of Mixolydian (b9, #9, b13)) and/or embellishing metaphors (as discussed in section '3.21: Universality').

Nevertheless, these factors did not prevent observations of how the 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174) may be shaped at a cultural level i.e., the 'Western listener'. These included: the altered ladder of fifths; the attribution of Ionian and Aeolian to tonic major and minor chords, respectively; Dorian's tonic minor potential amongst jazz fusion audiences; in 'nonfunctional relationships' (Nettles and Graf, 1997, pp. 162), the attribution of Dorian to minor seventh chords (-7), Lydian to major seventh (maj7), Lydian b7 to dominant seventh (7), and (arguably) melodic minor to minor major seventh (-maj7); a subverted tonic 'rule' where Ionian may still be attributed to an incorrect fundamental; the potential attribution of Dorian to 'nonfunctional' minor third intervals; and how movement through whole-tones and parallel third intervals may result in the attribution of a whole-tone GS.

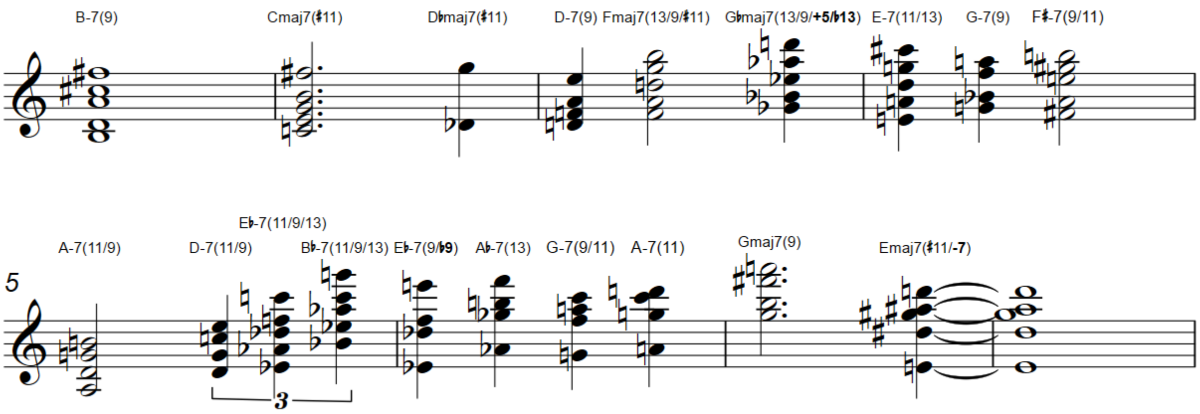
In addition to these core findings about Gravitonicity, the analysis showed that the gravitonic evolution of the chord-melody jazz guitar between the 'The 1930s and 40's' and '*Virtuoso* (Pass, 1973b) to Present' eras is complex and not necessarily unidirectional. Despite significant intra-era variation, the number of GS' per piece is relatively similar for each era: (first era) McDonough (8), Reinhardt (19), Mastren (8), Van Eps (19); (second era) Pass (16), Holdsworth (10), Monder (10), Grasso (17).

Reinhardt's and Van Eps' joint-victory may be accredited to their considerable exploration of established functional relationships – primarily tonality but also Reinhardt's use of harmonic minor modes – and the range of GS' that reside within them. Whilst this victory may indicate evolutionary stagnation (or perhaps regression) for the GS vocabulary of a single piece, the second era collectively features a wider GS vocabulary than the first (26 to 23). This is because, in addition to the tonal vocabulary (largely covered by Pass and Grasso), Holdsworth and Monder unlock other GS' through chromatic alterations in 'nonfunctional' environments e.g., Dorian (b9), Dorian (#11), Lydian (b9), Lydian (#5), and Lydian (b13).

In the future, the GS vocabulary of the chord-melody jazz guitar (and perhaps other harmonically complex music) may resemble a blend of established functional relationships, GS' that may be 'won' in 'nonfunctional' environments, and any other chromatically altered or exotic designs. It should not be forgotten, however, that 'nonfunctional' sequences of GS' may become established functional relationships through their increased use over time – as argued in section '3.13: Modularity and Functionality'.

The future of chord-melody jazz guitar may also witness increased use of UT's / the outer *g* values. In the selected repertoire, UT's were only identified in Van Eps' piece and, to a greater extent, Grasso's. However, their implementation via melodic chromaticism, the Z axis, and with memory traces of other gravi-tones, is not representative of their potential in independent Y axis structures alongside GS defining gravi-tones (CT's, T's, and AN's) – as demonstrated in section '3.5: Upper Tensions'.

As a solo instrument, the guitar's limited number of strings (usually six) mean that it can be challenging to integrate UT's alongside gravi-tones that define the GS. To illustrate that it is achievable, however, Example 4.7a shows an original reharmonisation (Shufflebotham, 2021) of the first eight bars of Bill Evans' *Time Remembered* (1982).



Example 4.7a: An original reharmonisation (Shufflebotham, 2021) of the first eight bars of Bill Evans' *Time Remembered* (1982), illustrating that the solo guitar is capable of accommodating UT's alongside GS-defining gravi-tones on the Y axis.

The texture is homophonic to emphasise the Y axis potentials and reduce memory detail in GSF. As observed with Holdsworth's and Monder's pieces, the predominantly 'nonfunctional' (Nettles and Graf, 1997, pp. 162) environment means that Dorian and Lydian may respectively prevail for all minor seventh and major seventh chords. This includes the three structures that house UT's: Gbmaj7(13/9/**+5/b13**), Eb-7(9/**b9**), and Emaj7(#11/**-7**).

In each case, the UT's are accompanied by GS-defining gravi-tones. With Emaj7(#11/**-7**), for example, Lydian is defined by: E (1 / *g*1), G# (3 / *g*3), and D# (maj7 / *g*4) as present tones; G (5 / *g*2) as a strong harmonic of the fundamental; and an A# (T#11 / *g*6) present tone to distinguish Lydian from Ionian. In particular, the presence of maj7 ensures that -7 (D♮) does not challenge its position as a CT, 'relegating' the latter to UT status (*g*9).

Finally, one of the purposes of the analysis was to assess the extent to which Joe Pass' accolades may be accredited to his gravitonic concept. Of the eight pieces analysed in this Chapter, Pass' is ranked fourth for the number of GS' used. All Pass' vocabulary and more can be found in Van Eps' piece of the first era. Furthermore, despite being a fraction of the length, Grasso's arrangement of the same standard (*Have You Met Miss Jones?* (Rogers and Hart, 1937)) features a greater number of GS'. In conclusion, therefore, Pass' accolades are likely not solely motivated by his gravitonic concept.

Chapter 5: Conclusion

> No fairer destiny could be allotted to any physical theory, than that it should of itself point out the way to the introduction of a more comprehensive theory, in which it lives on as a limiting case.
> (Einstein, 1920, pp. 90)

Before temporarily closing the book on Gravitonicity, this brief conclusion will focus on its prospective beneficiaries and opportunities for future research. It has repeatedly been stated that the 'neutral level' (Nattiez, 1990, pp. 12) and full models of Gravitonicity are hoped to benefit **practitioners**, **analysts**, and **educators**. Onto a blank map, these intentionally-vague labels represent the main 'continents' of Gravitonicity's potential influence. The following paragraphs will sketch some initial details for each continent. Any such cartography may not be finite, however.

It was posited in section '1.2: The Evolution of Harmony in Western Music' that, so long as pitch has a discernible presence, Gravitonicity is an inherent part of music of all times. Section '3.21: Universality' clarified this statement by acknowledging that: (1) instead of 'Spatial-Relations Concepts' (Lakoff and Johnson, 1999, pp. 30) (distance), some cultures may metaphorically map the quality represented by the *g* values to an alternative type of basic embodied understanding (e.g., 'color concepts' (pp. 23)); and (2) some cultures may not attribute meaning to the quality represented by the *g* values, or even music in general.

Within Gravitonicity's significant (if not universal) reach, its inherent presence means that practitioners understand the *g* values as intuitively as any other core musical parameter.

Therefore, it seems fair to question whether the models offer any practical benefit. Firstly, like any music theory, the systematisation readily allows the reproduction of events (e.g., specific gravi-tone / *g* value and GS), contextual understanding, and ease of communication with others.

Of greater significance, however, the complexity of the models arguably extends beyond the intuitive gravitonic palette of any individual. It seems unimaginable that anybody's long-term memory contains the *g* values – particularly those corresponding to UT's – for the practically-limitless number of GS'. Considering this ocean of GS' (with twelve possible fundamentals / *g*1's), it is even less likely that the intuition-guided practitioner could explore all networks of functional relationships. They may also be unable to controllably implement the unified time dimension (Z axis) or respect the fluid individuality of each listener's 'sonic saddle' (Shepherd and Wicke, 1997, pp. 174).

In other words, the frontiers of functional harmony are realistically only accessible through applied understanding of the models. This may represent the final word of the 'new modalism' (Vieru, 1993, pp. 16) which, once spoken clearly, may give way to an era that combines functionality with windows of atonality (or 'afunctionality'). Alternatively, an era of pure atonality / afunctionality would historically recall and confirm Arnold Schoenberg's status as a visionary.

Of course, practical application of the models does not need to be at the cutting-edge of functional harmony. If light 'jazz harmony' is desired without 'disturbing' a predominantly triadic environment, the closest T's in each GS may represent the 'safest' options. This may explain the prevalence of Ionian and Lydian's T9 (*g*5) in the 'add9' chords (1 3 5 T9) of country music. Similarly, for the jazz musician wishing to extend without uprooting their harmonic vocabulary, greater 'safety' may be offered by the closest UT's e.g., Ionian's UT+5/b13 (*g*8), Dorian's UTb9 and UTmaj7 (*g*8), Phrygian's UT9 (*g*8) etc.

Furthermore, the *g* values offer considerable potential for structure and form building. This was not previously addressed due to the focus on GSF (the 'mother' process) rather than activity within the GS'. In essence, a trajectory / trajectories of *g* values can be plotted onto any level of structure or form. These may represent the outermost *g* values (e.g., *g*2 in bar one to *g*6 in bar two), selected bands of closest to most distant *g* values (*g*3-*g*6 to *g*2-*g*7), or specific sets of *g* values (*g*1-*g*3-*g*5 to *g*3-g6-*g*7-*g*9). A trajectory could represent *g* values for every gravi-tone or only those deemed to be of structural significance.

Depending on their compositional input, a practitioner's use of *g* values as a structural device may be varyingly constrained. This will be of no concern to the composer with a blank manuscript, who may freely select GS', the fundamentals / *g*1's of which, and gravi-tones. For the arranger, however, an original melody and harmony would almost certainly clash with a separately conceived trajectory of *g* values. In these cases, it may be better-suited for any trajectory to have some degree of dialogue with the original composition – even for the most radical arrangements.

For a soloist playing in any style with pitched accompaniment, the former's potential for *g* value structuring may be constrained by the latter's suggestion of GS' and present gravi-tones / *g* values. In a blues, for example, any chordal accompaniment would likely supply dominant seventh CT's and – depending upon the style and musicians – possibly T's. Moreover, a bassist may reinforce the presence of the T's with passing notes, and perhaps integrate UT's through chromatic passing notes.

Despite these factors, the central role of the solo may allow its *g* value structuring to maintain independent coherency and narrative. An experimental trajectory of closest to most distant *g* value bands for a twelve-bar blues chorus might resemble the following: *g*1-*g*4 in bars one to four; *g*2-*g*6 in bar five; a leap up to *g*4-*g*9 in bar six; a temporary reduction of distance with *g*1-*g*7 in bars seven and eight; an ascent back to *g*4-*g*9 in bar nine; maximal ‘out’ playing with *g*8-*g*12 in bar ten; a facade of stability with *g*2-*g*4 in bar eleven; concluded with a final glimpse of *g*6-*g*10 in bar twelve.

For any practitioner using *g* values as a structural device, it should be remembered that each GS has a signature pattern of ‘absolute’ distance – as discussed in section ‘3.12: The Modular Structure of GSF’. Creative sensitivity for how distance varies for the same *g* values across GS’ (e.g., *g*7 feels closer in Lydian (T13) than Ionian (AN11)) is likely only developed through practical exploration.

Through ‘reverse-engineering’, all practical potentials of the models are equally available to the analyst – as demonstrated in Chapter 4. Further details of Gravitonicity’s models will continue to be uncovered through their analytical application to music from all times and styles. In the long-term, it may be possible to collate the findings of any/all analyses and work towards a ‘global’ understanding of GSF, GS vocabulary, and *g* value structuring.

For GSF, such an understanding would ideally factor each individual’s ‘sonic saddle’ (Shepherd and Wicke, 1997, pp. 174) into all ‘neutral level’ (Nattiez, 1990, pp. 12) observations. This may be unrealistic, however, given the complexity of GSF’s four qualities and the highly-specific (and constantly evolving) nature of each individual’s listening experience. Nevertheless, in pursuit of this goal, it should be considered that the ‘sonic saddle’ (Shepherd and Wicke, 1997, pp. 174) could become the focal point of an analysis. In other words, an analyst could observe how extramusical factors (e.g., social, cultural, political etc.,) determine the heard repertoire of a demographic or individual. These observations may then inform specialised accounts of GSF.

Because it subsumes standard Western harmonic theory, Gravitonicity also has potential to be integrated at all levels of education. The full extent of the models may be reserved for Higher Education. Chord Scale Theory, for example, is typically taught at this level by Berklee College of Music. Therefore, the components of the models that go beyond CST (e.g., UT's, the Z axis, the 'sonic saddle' etc.,) may be better-suited to advanced undergraduate or postgraduate study.

However, because the perceived distance is intuitively-understood, there is perhaps no reason not to introduce it at the earliest stages of education. From the outset of the student's journey, it may be beneficial to consciously recognise that the fifth usually feels closer in major and minor triads than the third. Perhaps the *g* values and gravitonic scale degree organisation (as introduced in Example 3.1b) will become a standard accompaniment to the notation of chords, scales, and arpeggios in school and grade exam textbooks?

Finally, nine opportunities for future research were noted at various points of the text. In order of their mentioning, these included: (1) using information from the 'poietic dimension' (Nattiez, 1990, pp. 11) to initiate an analysis i.e., the process of creation and how it has been influenced; (2) the 'neutral level' (pp. 10) modelling of GS' for other tuning systems by analysing the spectra of appropriately-tuned pitches; (3) the potential distinction of shared *g* values by building upon the spectral analysis with an alternative methodology; (4) charting (qualitatively or quantitatively) the 'absolute' distance pattern for each GS; (5) the prospect of whether two GS' can be perceived simultaneously i.e., bi/polytonality and bi/polymodality; (6) whether there is perceivable distance between GS', with and without functional relationships; (7) the derivation of all potential GS' from Olivier Messiaen's 'Modes of Limited Transpositions' (1956, pp. 58), the potential functional relationships that may bind them together, and how these are 'opposed to or mixed with' (pp. 67) other functional relationships; (8) how/if distance and motion interact at the 'neutral level'; and (9) how/if the "Pitch Distance is Physical Distance" and 'Musical Succession Is Physical Motion' (Larson, 2012, pp. 82) metaphors might interact in the 'esthesic dimension' (Nattiez, 1990, pp. 12).

Given the scope of Gravitonicity, these are far from the only conceivable opportunities for future research. Such opportunities are multiplied when considering Gravitonicity's potential status in the general theory of music. Yet, Music's very own 'gravitation' may be at the source of it all.

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Appendix: The Attribution of GS' in Functional Relationships

A summary of how *The Chord Scale Theory & Jazz Harmony* (Nettles and Graf, 1997) maps 'chord scales' (pp. 17) (GS') to the harmonic contexts of tonality, modality, blues, and 'nonfunctional relationships' (pp. 162).

<u>A.1: Diatonic Harmony</u>

- 'use the diatonic scales associated with the displacement of the Ionian scale' (pp. 33):

Imaj7: Ionian

II-7: Dorian

III-7: Phrygian

IVmaj7: Lydian

V7: Mixolydian

V7sus4: Mixolydian 7sus4

VI-7: Aeolian

VII-7b5: Locrian

<u>A.2: Dominant Chords and Diatonic Function</u>

- 'dominant 7th chords create analytical problems. They are the most unstable chords but have the greatest potential for deception' (pp. 43). There are five types of dominant seventh chords with diatonic functions: primary, secondary, sequential, substitute, and sequential substitute. These are discussed individually in the following sections. Related II-7 chords are also addressed.

A.2.1: Primary

V7/I: Mixolydian, Mixolydian with alterations, altered, whole-tone

*Mixolydian with alterations = the use of up to three alterations available from: b9, #9, b5, and b13. The use of all four would result in an altered scale.

A.2.2: Secondary

V7/II: Mixolydian (b13), Mixolydian (b9, #9, b13), altered, whole-tone

V7/III: Mixolydian (b9, #9, b13), altered, whole-tone

V7/IV: Mixolydian, Mixolydian with alterations, altered, whole-tone

V7/V: Mixolydian, Mixolydian with alterations, altered, whole-tone

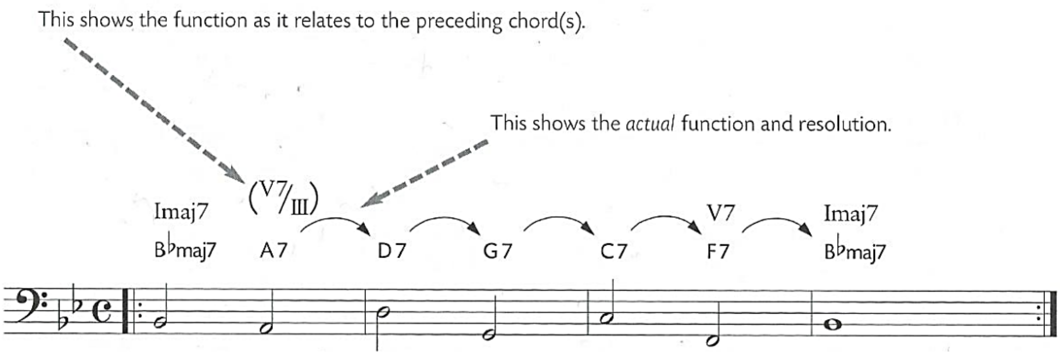
V7/VI: Mixolydian (b9, #9, b13), altered, whole-tone

- ‘When V7/IV *resolves* to IVmaj7, the nondiatonic pitch of this secondary dominant is retained by the listener […] and, *the chord scale for the IVmaj7 is Ionian*’ (pp. 47).

A.2.3: Sequential

- ‘nondiatonic dominant chords that resolve to other nondiatonic chords such as another sequential dominant or the related II-7 of a sequential dominant. There is an expectation for sequential dominants to eventually return to the diatonic. […] The roots are diatonic' (pp. 51).

- 'In classical harmony the term Consecutive Dominants (moving in a cycle of fifths) is more common than Sequential Dominants' (pp. 56).
- The text uses Example A.2.3a to illustrate how 'the first chord of a sequence or pattern may represent a secondary dominant resolving deceptively' (pp. 52). Instead of resolving to III-7 of Bb major (D-7), A7 deceptively resolves to D7. This is shown by the inclusion of parentheses around 'V7/III'.

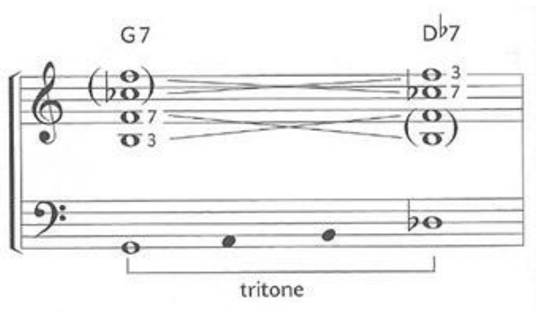


Example A.2.3a: A secondary dominant chord (A7 / V7/III in Bb Major) resolving as a sequential dominant (pp. 52).

- 'The chord scale for any chord that moves deceptively is the chord scale based on the parenthetical analysis. That is the chord's *functional sound*. The A7 above would, as V7/III, use a Mixolydian (b9, #9, b13); The D7, as (III7), a sequential dominant, would use Mixolydian' (pp. 55).

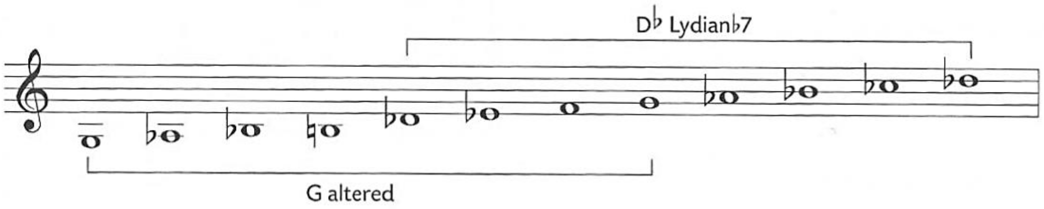
A.2.4: Substitute

- ‘If the tritone is inverted, the enharmonic spelling of the 3rd and 7th can be heard exchanging positions resulting in a different dominant chord root that contains the same tritone […] These are substitute dominant chords. They are also known as *tritone substitute* chords because they share common tritones and their roots are a tritone apart’ (pp. 57). The text illustrates this with Example A.2.4a – ‘G7 is V7 and Db7 will be analyzed as subV7’.



Example A.2.4a: Tritone substitute chords (pp. 57).

- The chord scale for substitute dominant chords is Lydian b7 which ‘contains the same notes as the altered scale for the dominant’ (pp. 58), as illustrated by Example A.2.4b.

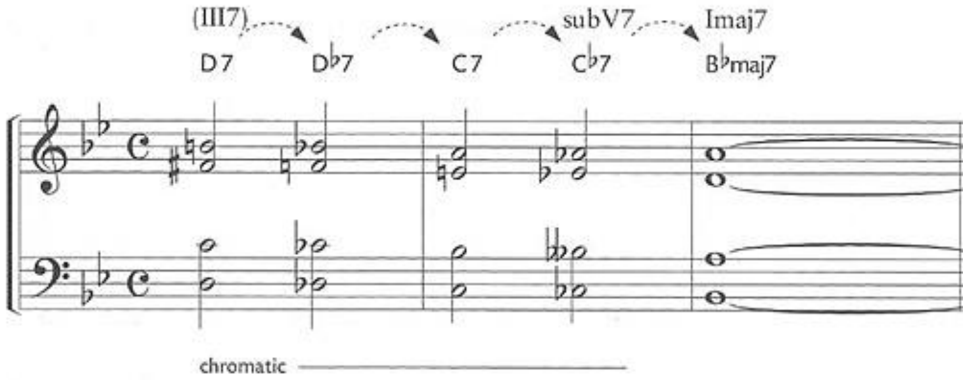


Example A.2.4b: Tritone substitute chord scales (pp. 58).

- ‘Lydian b7(#9) *can be an alternative chord scale* for subV7 of Imaj7, IVmaj7, or V7’ (pp. 59).
- Symmetric dominant: At the same point the text briefly notes that, presumably in all circumstances, ‘The symmetric dominant chord scale is also an alternative for the Mixolydian and the Lydian b7 scales’. Later in the text, it is elaborated that ‘The lower half is altered (b9, #9); the top half is Lydian b7 (#11, 13)’ (pp. 93) and that the use of the chord scale depends ‘on the choice of the player/writer and circumstances’ (pp. 123).
- ‘Another possibility of deriving substitute dominants is based on V7 with a lowered 5th’ (pp. 60): subV7b5 is the second inversion of V7b5. Both chords use the whole-tone scale.
- Augmented Sixth Chords: ‘Although there is no such term as substitute dominants known in traditional harmony, composers of the 18th century utilized the effect of approaching the dominant or tonic chromatically. Classified as Augmented Sixth Chords, they accomplish the function of substitute dominants. […] Spelled enharmonically this chord represents a dominant seventh chord structure. In jazz context this type of chord is not considered an augmented 6th chord anymore but a substitute dominant chord’ (pp. 61-62).

A.2.5: Sequential Substitute

- Similar to sequential dominant motion but with a 'more chromatic sound as opposed to a dominant sound […] The chord scale for each chord is determined by either chromatic sound or dominant function. A choice must be made based on the chords which surround each dominant chord. The chord scale choice may be based on the first or last chord of the series' (pp. 64). This is illustrated in Example A.2.5a where 'the Cb7 is functioning as subV7 with a Lydian b7 scale', meaning that each of the preceding chords can also use Lydian b7. Conversely, the D7 'sounds like a sequential dominant using a Mixolydian scale', so each of the subsequent dominant chords could also use Mixolydian.



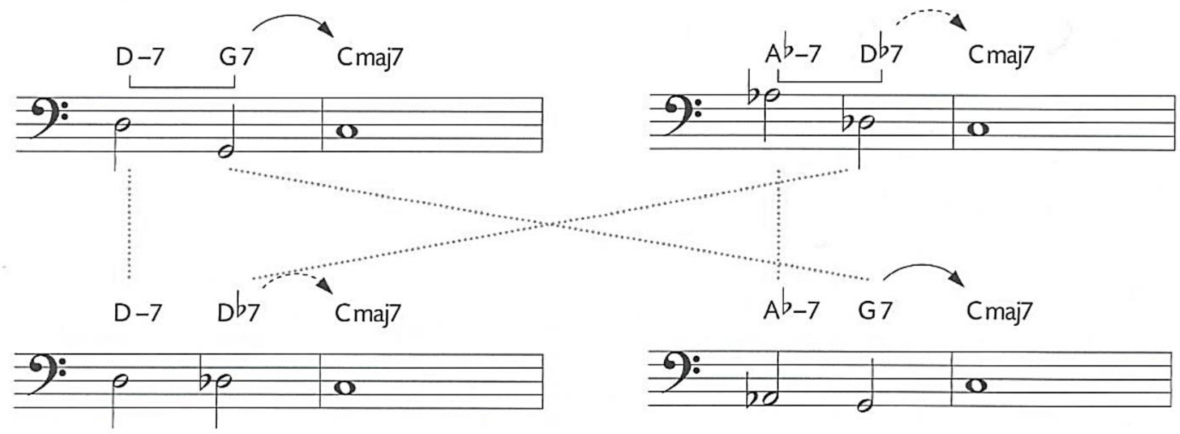
Example A.2.5a: Sequential substitute motion (pp. 64).

A.2.6: Related II-7

- ‘Any dominant chord *may be preceded* by its related II-7 except I7 and IV7 in the blues. […] The related II-7 may also be diatonic and represent *a dual function chord*’ (pp. 67) e.g., the E-7 chord in Example A.2.6a could be interpreted as III-7 (Phrygian) of C major or as II-7 (Dorian) of D major.

Example A.2.6a: Related II-7 chords (pp. 68).

- ‘The related II-7 chords of the substitute dominants are nondiatonically rooted. With the related II-7 chords of the dominant and its substitute, a four-way relationship can exist […] *Either of the dominants may be preceded by the other dominant’s related II-7 chord*. […] Both -7 chords exist because of their relationship to their related dominant chord’ (pp. 70-72). This ‘four-way relationship’ is shown in Example A.2.6b. In all four contexts, the minor seventh chords use a Dorian chord scale.



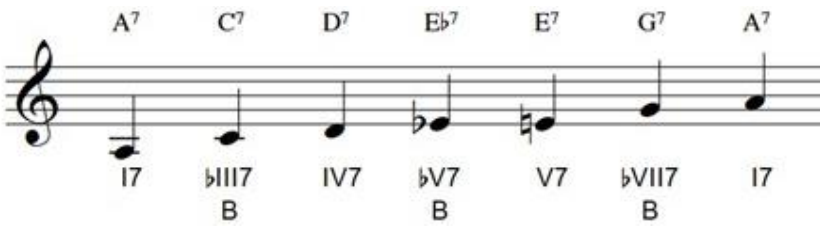
Example A.2.6b: The ‘four-way relationship’ (pp. 70).

A.3: Dominant Chords with Special Functions

- There are two types of special function dominant chords: ‘Special Function Blues Chords’ (pp. 122), and ‘Special Functions for Secondary Dominants’ (pp. 124).

A.3.1: Special Function Blues Chords

- These chords have blue note roots. Example A.3.1a has been generated from the text and shows an A blues scale with each note acting as the root of a dominant seventh structure. The blue notes (labelled B) provide three special function dominants (bIII7, bV7, bVII7) which may ‘function as diatonic blues chords instead of their potential functions as subV of II, IV, and VI respectively. […] they usually cadence to tonic or move by diatonic blues scale step' (pp. 123).



Example A.3.1a: Chords with blue note roots.

- The chord scales for the blue note rooted sevenths could be: 'Lydian b7 (describing motion *other than* down a perfect fifth), or any form of Mixolydian (describing expectation for *resolution* down a perfect fifth), or symmetric dominant'.

A.3.2: Special Functions for Secondary Dominants

- 'All secondary dominant chords will be found having functions other than the norm. V7/IV occurs as I7; V7/II occurs as VI7; V7/III occurs as VII7; V7/V occurs as II7; V7/VI occurs as III7' (pp. 124).

VI7: 'most often a form of Mixolydian' (pp. 125).

VII7: 'any form of Mixolydian, altered, Lydian b7, or symmetric dominant'.

II7: 'a choice between Lydian b7 and, more commonly, any form of Mixolydian' (pp. 126).

III7: ‘Any dominant chord scale’ (pp. 127).

A.4: Minor Key Harmony

- ‘The basic considerations used in determining the chord scales for major key related chords apply to chords found in minor keys. The diatonic chords use diatonic chord scales. However, there is much more freedom of choice because the 6th and 7th scale degrees may be either natural or raised’ (pp. 91).

I-7: ‘most often a *Dorian* chord scale’ (pp. 76); ‘Dorian or Aeolian. […] Phrygian is a potential scale, especially if the melody is phrygian minor (unusual)’ (pp. 91).

I-6: Dorian AN-7 or melodic minor

I-maj7: melodic minor or harmonic minor

I-(triad): ‘either a scale using degrees 1 through 5 (all the common pitches from the above scales) or any of the above scales assuming the melody conforms to the choice’.

bIImaj7: Lydian

II-7: Phrygian or Dorian (b9)

II-7b5: Locrian

bIIImaj7: ‘usually a Lydian scale’ (pp. 76); ‘Lydian or Ionian’ (pp. 91).

IV-7: Dorian

IV-6: Dorian AN-7 or melodic minor

IV7 (V7/bVII): Lydian b7 or Mixolydian

V7(b9): Mixolydian (b9, #9, b13)

V7: Mixolydian (b13)

V-7: Aeolian if ‘functioning as a tonic minor chord from natural minor’ (pp. 76); Dorian if heard ‘as the related II-7 of V7/IV’ (pp. 77).

bVImaj7: Lydian

bVI7: Lydian b7

VI-7b5: Locrian or Locrian (♮9)

bVII7 (V7/bIII): Lydian b7 or Mixolydian

bVIImaj7: 'Lydian to reflect its nontonic function' (pp. 76). Unclearly, the text later mentions only 'Ionian' (pp. 91) but without the justification that Lydian receives.

VII°7: '(rarely used) The chord scale is a displacement of the harmonic minor scale' (pp. 91) '(starting on the 7th degree) or V7 (Mixolydian b9, #9, b13) starting on the 3rd (leading tone root)' (pp. 121).

- German Augmented Sixth Chord: 'Like subV7/V the nondominant bVI7 chord is also related to the traditional German augmented sixth chord […] While the dominant functioning Ger+6 (subV7/V) is derived from a diminished chord with secondary dominant function (upper structure of V7(b9)/V), the nondominant Ger+6 (bVI7) is derived from the same diminished chord with chromatic function (enharmonically spelled) […] In contemporary usage both the subV7/V and bVI7 chord are spelled the same as a dominant seventh chord structure built on the bVI scale degree […] If the bVI7 is a cadence chord without dominant function […] it uses a Lydian b7 chord scale. If it has a substitute dominant function as subV7/V it also uses Lydian b7' (pp. 81-82).
- Neapolitan Sixth Chord: 'a modal interchange chord from parallel Phrygian. […] The origin of the bIImaj7 chord traces back to the 17th century. […] Contrary to today's analysis the N6 was considered a IV-chord and not a form of a II chord. In the later 18th and 19th century the Neapolitan chord was employed also in a major context and with increasing frequency in root position (N) producing more stability and

independence' (pp. 83). It is mentioned later in the text (pp. 133) that the bIImaj7 chord uses a Lydian chord scale.

A.5: Blues Chord Scales

- There are three functional chord types in a basic blues: I7 (tonic), IV7 (subdominant), and V7 (dominant function or moving 'diatonically to the IV7' (pp. 100). The authors note that 'the chord scales associated with blues can be varied' (pp. 105) because the 'non-chord tones for each chord can be derived from the blues scale or the major key or minor key function for the chord'. Also included below are other chords less commonly found in blues progressions that use chord scales which are not directly 'borrowed from major or minor key harmonies' (pp. 106).
- 'Natural 11 is not an available tension for dominant chords. However, in blues, it is very common to find natural 11 as a stressed melodic pitch on the primary I7, IV7, and V7' (pp. 107).
- 'the symmetric dominant scale is worth investigating for potential usage' with the following dominant chords.

I7: 'The most common chord scale for the I7 chord […] is *Mixolydian #9*' (pp. 105). Additionally, the text states that 'Other tonic chord scales can be fashioned using diatonic pitches from parallel tonalities' and proceeds to list Mixolydian, Lydian b7(#9), and Dorian.

IV7: ‘most often uses a Mixolydian scale’ (pp. 105).

V7: ‘(borrowed from major key harmonies) is either a *Mixolydian* scale, or a *Mixolydian with alterations*, or an *altered* chord scale’ (pp. 106).

V7/II: ‘a Mixolydian b9, #9, b13 chord scale. (A natural 9 would imply a major key, #9 (1 of the key) and b9 (b7 of the key) are both blues melodic pitches.)’.

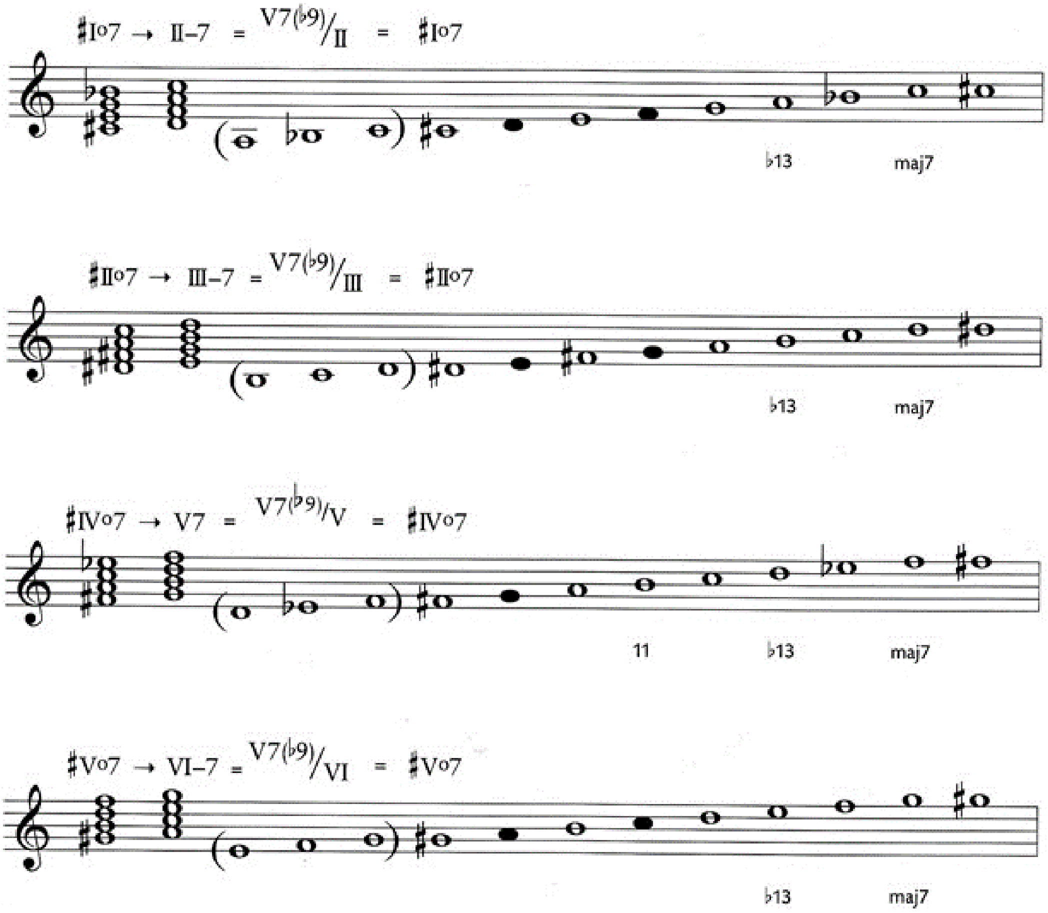
III-7b5: ‘when acting as an approach chord to IV7, like most -7b5 chords, uses a Locrian chord scale (Locrian ♮9 is also possible since the ♮9 is a blue note)’.

A.6: Diminished Seventh Chords

- ‘diatonic functioning diminished 7th chords can be categorized as either: ascending to the diatonic chord a half step higher, or descending to the diatonic chord a half step lower, or an auxiliary of the tonic or dominant chord (with no root movement) […] A diminished 7th chord contains 2 tritones, so there is a possibility of these chords having dominant function. With regard to the ascending diminished chords, the tritone of the secondary dominant of the target chord is present. […] However, the descending and auxiliary diminished do not contain the secondary dominant’s tritone, therefore, the descending and auxiliary diminished are derived from chromatic resolution as opposed to dominant resolution. This is an important fact with regard to chord scale choices’ (pp. 113-114).
- Symmetric Diminished: ‘there is a problem with the symmetric diminished scale and the characteristics of the diminished 7th chords mentioned

above. These chords have *diatonic function*, hence, the tensions should be *diatonic*' (pp. 114). Because the Tensions of symmetric diminished do not indicate any recognisable key, it is therefore 'an appropriate scale for use when the diminished 7th chord is *not* functioning diatonically […] For the diatonic functioning diminished chords, a more appropriate chord scale must rely on the diatonic functioning *secondary dominant* chords which contain the necessary 8 notes. These are Mixolydian scales with b9 and #9' (pp. 114-115).

- Ascending: 'Because the ascending diminished chords are derived from the *secondary dominant of the target diatonic chord of resolution*, that secondary dominant chord scale is the choice for the diminished chord scale' (pp. 115). For example, in C major, a C#°7 ascending to D-7 – of which A7 is the secondary dominant – would use the same pitches as an A Mixolydian (b9, #9, b13) chord scale. The text illustrates this with the top stave of Example A.6a. The annotated Tensions ('b13' and 'maj7') and Avoid Notes (the 'filled-in' pitches) correspond to the C# fundamental. The remaining staves in Example A.6a show other ascending contexts.



Example A.6a: Chord scales for ascending diminished seventh chords.

- Descending and Auxiliary: ‘The scale of choice is based on the enharmonic similarities between the ascending diminished chords and the chromatically derived diminished chord because the key remains unchanged’ (pp. 116). The chord scales shown in Example A.6b ‘begin with the root of the related enharmonic chord. The starting pitch of the scale is the root of the diminished chord. The tension numbers represent those for the enharmonic diminished chord’.

Example A.6b: Chord scales for descending and auxiliary diminished seventh chords.

- #IV°7: 'two chord scales usable […] V7(b9) of V because of dominant derivation […] and V7(b9) of III because it is enharmonically the same as #II°7 […] Similarly, it is possible to use the dominant functioning chord scale for #IV°7, which contains an additional tension, for the enharmonically similar #II°7, bIII°7, and I°7 chords […] The choice of chord scale for these diminished chords must take into consideration the most appropriate tensions' (pp. 116-117).

A.6.1: #IV-7b5

- 'included here because it is closely related to diminished 7th chords in structure and function' (pp. 119).
- 'uses a diatonically oriented Locrian chord scale. Locrian (♮9) is also a potential chord scale when movement is expected to a IV- chord. (♮9 represents the -3rd of the IV- chord)' (pp. 121).

A.7: Modal Interchange

- 'The borrowing of chords from parallel tonalities' (pp. 128). This was illustrated by the variability of the 6th and 7th scale degrees of minor key harmony, which generated a considerable array of chords and chord scale options. These were derived from the modal interchange of the four minor scales shown in Example A.7a. Examples A.7a–A.7c are all original but generated in-line with Nettles and Graf's prose.

Natural	I-7	II-7b5	bIIImaj7	IV-7	V-7	bVImaj7	bVII7
Harmonic	I-(maj7)	II-7b5	bIII+maj7	IV-7	V7	bVImaj7	VII°7
Melodic	I-(maj7)	II-7	bIII+maj7	IV7	V7	VI-7b5	VII-7b5
Dorian	I-7	II-7	bIIImaj7	IV7	V-7	VI-7b5	bVIImaj7

Example A.7a: Modal interchange for minor key harmony.

- ‘The other common form of modal interchange is borrowing natural minor chords for use in the parallel major key’ (pp. 129), as shown in Example A.7b (Major = Ionian, Natural Minor = Aeolian).

Major	Imaj7	II-7	III-7	IVmaj7	V7	VI-7	VII-7b5
Natural Minor	I-7	II-7b5	bIIImaj7	IV-7	V-7	bVImaj7	bVII7

Example A.7b: Modal interchange for parallel major and natural minor scales .

- ‘In addition to Aeolian, the other diatonic modes are the most likely candidates for producing usable chords and chord scales’ (pp. 130), as shown in Example A.7c.

Ionian	Imaj7	II-7	III-7	IVmaj7	V7	VI-7	VII-7b5
Dorian	I-7	II-7	bIIImaj7	IV7	V-7	VI-7b5	bVIImaj7
Phrygian	I-7	bIImaj7	bIII7	IV-7	V-7b5	bVImaj7	bVI-7
Lydian	Imaj7	II7	III-7	#IV-7b5	Vmaj7	VI-7	VII-7
Mixolydian	I7	II-7	III-7b5	IVmaj7	V-7	VI-7	bVIImaj7
Aeolian	I-7	II-7b5	bIIImaj7	IV-7	V-7	bVImaj7	bVII7
Locrian	I-7b5	bIImaj7	bIII-7	IV-7	bVmaj7	bVI7	bVII-7

Example A.7c: Modal interchange between parallel modes.

- In all tables (Example A.7a-A.7c), chord scales for each symbol are based on the displacement of the given mode/scale – as was the case with the Diatonic Harmony. For example, in the Dorian row of Example A.7c: I-7 = Dorian; II-7 = Phrygian; bIIImaj7 = Lydian etc.

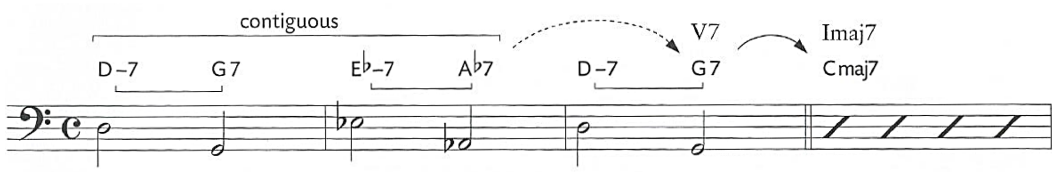
A.8: Nonfunctional Harmony

- ‘where symmetry exists, nonfunctional relationships usually exist’ (pp. 162). The text uses John Coltrane’s *Giant Steps* (1960) as an example and observes that there are ‘three tonal centers, spaced a major 3rd (minor 6th) apart (B, G, Eb)’ (pp. 163), ‘The melody is symmetric’, and ‘all three tonics carry equal weight’. It is explained that the chord scales ‘would normally reflect the diatonic of each individual tonal center (Ionian, Mixolydian, and Dorian respectively for the Imaj7, V7, and II-7 chords […] these are the scales used by John Coltrane for his improvisation.

However, because each tonic is as strong as the others, and the relationship between the three tonalities is symmetric, a choice of Lydian, Lydian b7, and Dorian for the same chords is potential' (pp. 164).

A.8.1: Contiguous Dominants

- 'Nonfunctional progressions are also found in predominantly functional tunes. The most common occurrence are contiguous dominants – dominants with or without their related II-7 chords which appear next to each other but not functioning to each other' (pp. 166). This is illustrated by Example A.8.1a.

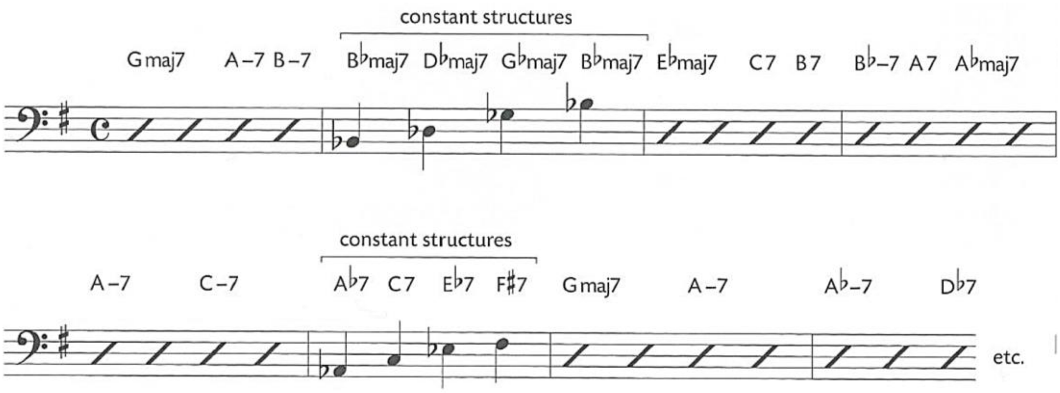


Example A.8.1a: Contiguous dominants.

- 'chord scales for the contiguous dominants and their related II-7 chords will be […] Dorian/Mixolydian. However, some freedom exists (especially when the related II-7 is not present), because one is dealing with dominant chords whose expectation is not to resolve down a perfect fifth, therefore Lydian b7. Where the contiguous dominant progresses in a continual pattern, an option is to use the chord scale for the first chord of the series. *Symmetric dominant* is a particularly good scale choice for *symmetric* nonfunctional *dominant* chords' (pp. 168).

A.8.2: Constant Structures

- 'Chords of the same quality which move in constant root pattern' (pp. 169). The text illustrates this with measures two and six of Example A.8.2a, a reharmonisation of the jazz standard *Here's That Rainy Day* (Van Heusen, 1953).



Example A.8.2a: Constant structures in *Here's That Rainy Day* (Van Heusen, 1953).

- 'as with other nonfunctional situations a functional analysis will not define the most correct chord scale choices. The chord scales best used are Lydian because there is no specific tonic chord in control of the pattern' (pp. 169). Likewise, for a context using dominant seventh chords, the correct chord scales would be Lydian b7, and for minor seventh chords, it would be Dorian.