

**CHARACTERISTICS
OF
HEAVY METAL CHORD STRUCTURES**

**Their Acoustic and Modal Construction, and
Relation to Modal and Tonal Context**

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Contents

1. Introduction.....	1
1.1. Heavy Metal as a Musical Genre – Development and Boundaries	4
1.2. A Notion on Transcriptions and Reductive Notation	8
2. The Acoustics of the Loud and Distorted Chords.....	10
3. The Problem with the Chord Roots of Dyads.....	22
3.1. The Chord of the Open Sixth.....	22
3.2. The Chord of the Fourth	26
4. Scales, Modes and Voice Leading in Heavy Metal	30
4.1. Pentatonic and Blues Scales.....	30
4.2. Modal Scales and the Modal System.....	33
4.3. Major/Minor Tonal Influences in Heavy Metal.....	37
4.4. Mixed Scalar Contents and Voice leading Derived from Different Traditions	43
5. Chord Structures and Their Relation to Modal/Tonal Context.....	49
5.1. Modal Altered Chords.....	50
5.2. Tonal Altered Chords.....	55
5.3. Acoustic Chords and Chromatic Altered Chords.....	56
5.4. Diatonic Vertical Dissonances.....	61
6. Conclusions.....	65
References	67
Discography	72
Appendix I.....	74
Appendix II	77

1. Introduction

Heavy metal music has been under little academic scrutiny, although some research has been done from cultural or sociological standpoints (e.g. Walser 1993, Berger 1999). Unlike its precedents, the aim of this study is to provide a music analytical perspective to the musical genre, or genres, known as heavy metal. The main object is to illuminate the melodic and harmonic features that are the most significant to this music genre. Furthermore, new tools for music analysis are presented throughout the course of the study. These analytical tools are based on music theory and acoustics in such a way that the starting point has been the music as it sounds. That is to say, the analyses presented here are built to reflect the characteristics of the music. This definitively contrasts with approaches which take a given theory or an analytic model as a starting point and try to fit the music accordingly – this can easily happen if we look at heavy metal music through the theories of major/minor tonal music. By using musical features as a starting point, this study aims particularly to make justice to the music itself.

Rock music has mainly been studied from perspectives other than that of the music – rock music has generally been studied from historical (e.g. Stuessy 1994) or sociological standpoint (e.g. Frith 1983), but rarely from a purely musicological standpoint. It is not until quite recent years that the musicological approach has been extensively applied to rock music by scholars like Walter Everett (2000a, 2001), Allan Moore (1992, 1995, 2001, 2003), and John Covach (1997, and Covach & Boone 1997). Although, rock music is beginning to gain wider acceptance in the field of music theory and analysis, there still are very few such studies on heavy metal. Harris M. Berger (1999) has studied musical experience of death metal musicians by ethnographic case studies, and tried to find relationships between musical activity and large-scale political and economical conditions, and “to provide new insights into the interpretation of musical experience and the role of expressive culture in society” (Berger 1999: 2-3). Robert Walser (1993: xiv) draws “attention to the *music* of heavy metal, in the ways that are both textually specific and culturally grounded.” Besides the historical and cultural aspects of heavy metal, he offers many important insights into the music – especially on heavy metal’s appropriation of classical music (Walser 1993: 57-107;

published also in Walser 1992). While both Berger and Walser incorporate music analysis in their work, their main concerns are somewhat socio-cultural; musical analysis itself is, although important, of secondary concern.

While I am not aiming to undermine the importance of these (or any) kinds of approaches, it seems to me that much basic work with musical structures has to be done. This is to know first how the music works before one can thoroughly explore, say, “musical experience,” “musical meanings,” or other fields involving music. In Allan Moore’s (2001: 6) words: “Although the sounds of rock cannot, ultimately, be divorced from their [social and cultural] setting, they must be loosely separated in the interim, if the listening act is to receive adequate attention in any discussion of the cultural practices of rock.” The study in hand is explicitly concerned with music analysis, and through music analysis paving the way for the forthcoming studies that may have wider perspectives.

In heavy metal music, there are many features in musical structures similar to the so-called “common practise” tonal music.¹ However, one can find many musical characteristics that derive from other sources as well. Considering the melodic and harmonic aspects specific to heavy metal, there are at least four overlapping fields that have to be covered. These fields include 1) modality, 2) voice leading, 3) chord structures in relation to tonal and modal context, and 4) functional tonal hierarchies. Because the issues presented here result in lengthy discussions due to their novelty, the functional tonal hierarchies in heavy metal have been ruled out of this study. However, they will be covered in my future studies. The main concerns here are with the acoustic and modal characteristics of heavy metal chords. Chapter 2 presents the acoustic features that interlock with the practises of chord constructing. Furthermore, some extra attention is paid to a specific chord that is definitive to the genre – namely, the “power chord” that in its simplest form consists of an interval of a perfect fifth or a fourth. This relates closely to the issues presented in Chapter 3, where the position of the chord root in heavy metal and the problems with its definitions are discussed. Chapter 4 covers the most important traditions that have formed the basic scalar elements of heavy metal – the blues-derived pentatonicism, modal scales, and the common-practise tonal music.

¹ Here, “common practise tonal music” is used to refer to the classical-romantic period in the Western art music.

The appearances of these traditions in heavy metal are discussed with some notions to the voice leading practises. Chapter 5 draws the previous chapters together in suggesting a categorizing system for heavy metal chords according to their relations to modal and tonal contexts.

The analyses made here have a strong emphasis on the vertical appearances of heavy metal chords. By no means is this meant to undermine the horizontal aspects of heavy metal harmony. On the contrary, the analyses made here look forward to creating a basis for the more horizontally oriented analyses. After all, a thorough investigation of the construction of individual chord structures is a necessary first step for more elaborate studies.

The musical examples presented in this work start from the ancestors of heavy metal in the late 1960's and go through the 1970's to the mid 1980's – now considered as the golden era of heavy metal (Walser 2004a). Furthermore, there are some more contemporary examples, too (e.g. the analysis of Mercyful Fate's "Banshee" in Chapter 5). As the forefathers of heavy metal bands and artists like Jimi Hendrix, Cream and The Who are taken into an account – i.e. those, who had a profound influence on the formation and the development of the genre in the following decades. As a musical genre, heavy metal was defined in the early seventies by such bands as Led Zeppelin, Deep Purple, and Black Sabbath. From then on, this study is mainly concerned with bands ranging from the so-called "new wave of British heavy metal" of the mid and late seventies (bands like Judas Priest, Iron Maiden, and Motörhead) to the mid eighties with bands like Rainbow, Dio, and Ozzy Osbourne. Although the bands in question here are mainly of British origin, some mention is also made to the ones from other parts of Europe (Accept from Germany, Mercyful Fate from Denmark), the United States of America (Metallica), and Australia (AC/DC). The heavy emphasis on the British is grounded on the unquestionably overriding effect that British metal has had on the formation of the genre at least until the mid eighties – this has been stated in previous studies (see, e.g. Moore 2004; Walser 2004a; 1993: 9-12). In spite of the necessity of dealing with a certain limited time span, the study in hand is not a historical, but rather a theoretical and analytical one. The musical examples are meant to illuminate the theoretical and analytical points made throughout the work.

1.1. Heavy Metal as a Musical Genre – Development and Boundaries

According to Robert Walser (1993: 7), “the term ‘heavy metal’ has been applied to popular music since the late 1960’s.” Usually scholars refer to Steppenwolf’s “Born to be wild” (1967) as the first rock song to popularize the term² (Moore 2004; Walser 1993:8). Hard rock bands of the late 1960’s – for example, The Who, Cream, The Yardbirds and The Jeff Beck Group from Britain, and Jimi Hendrix from America – are nowadays widely recognized as having had major influence on the formation of heavy metal over the following decades (Walser 2004a; 1993: 9; Obrecht 1984: 8; “Heavy Metal” 2004). Those bands “developed a more distorted guitar sound and heavier drums and bass that led to separation of heavy metal from other blues-based rock” (Walser 2004a). Jimi Hendrix is sometimes credited for releasing “the first real heavy metal hit” “Purple Haze” in 1967 (Walser 1993: 9), and Led Zeppelin is more than often acknowledged as the “the first true metal band” or as the founders of heavy metal.³ Their album *Led Zeppelin II* (1970) codified the new genre, together with Black Sabbath’s *Paranoid* (1970) and Deep Purple’s *Deep Purple in Rock* (1970) (Walser 2004a; 1993: 10). During the 1970’s, several followers of these three bands (many of them from America) modified heavy metal into more accessible form (“Heavy Metal” 2004). In general, this meant simpler and more pre-arranged structures in contrast to early heavy metal’s often complex and improvised forms – this can be clarified by comparing, for instance, the music of Deep Purple or Black Sabbath to that of Kiss or AC/DC. Still, at the time there were significant contributions made to the popularity of the genre: “performers such as AC/DC, Judas Priest, Kiss and Alice Cooper toured incessantly with elaborate stage shows, building a fan base for an internationally-successful style” (Walser 2004a). However, “popularity waned at the end of the decade, but the early 1980s brought the ‘new wave’ of British heavy metal to revive the genre” (ibid.). The new wave of British heavy metal (sometimes abbreviated as NWOBHM⁴) included bands like Judas Priest, Iron Maiden and Motörhead (“Heavy Metal” 2004). Robert Walser (2004) sums up the next decades in the following:

² The song lyrics contain a line “heavy metal thunder”.

³ See, e.g. “Heavy Metal” 2004, or “Led Zeppelin” on Russ 2004.

⁴ See, e.g. Russ 2004: “What does NWOBHM stand for?” on the FAQ section of *The BNR Metal Pages*, <http://www.bnrmetal.com/pages/faq.htm> (accessed May 7, 2004).

The 1980s brought on the one hand a wave of gender-bending, spectacular ‘glam’ metal from bands such as Poison and Mötley Crüe, and, on the other hand, the widespread adaptation of chord progressions and virtuosic practices from 18th-century European models, especially Bach and Vivaldi, by influential guitarists such as Van Halen, Randy Rhoads [from Ozzy Osbourne] and Yngwie Malmsteen. Heavy metal was the most popular genre of rock music worldwide during this decade, even as harder underground styles developed in opposition to the pop-oriented metal of groups such as Bon Jovi. Metallica was the most influential band in trash metal. In the 1990s, Metallica, Van Halen, Ozzy Osbourne and other veteran performers continued their success, but the term heavy metal was less often used to distinguish them from the rock mainstream. New groups such as Soundgarden, Korn and Rob Zombie continued the heavy metal tradition in some ways, but were not particularly concerned with claiming the genre label, which had lost much of its prestige.

Still unlike Walser’s notion above, the nineties saw the rise of various extreme heavy metal subgenres within which the bands usually claimed not only to be metal, but even “heavier” metal than anyone before. The subgenres that are usually called “black” or “death metal” include such bands as Bathory, Mayhem, Emperor, and Dimmu Borgir. Black and death metal bands derived their music mainly from trash metal (many times adding synthesizers or other keyboards to their ensembles), but owe as much to Black Sabbath.⁵

Furthermore, in the past few years many heavy metal bands that were popular in the eighties have seen a revival in their success and have possibly re-launched the “classic” form of heavy metal to a new rise. This can be seen in the increase in record sales and substantial touring often conducted on the massive scale of the 1980’s by bands like Iron Maiden, Ozzy Osbourne, Deep Purple, and Black Sabbath. One reason for this might be that heavy metal fans of the eighties, now in their thirties and forties, have both enough money and enough nostalgia to support their favourite bands.

On the Boundaries of the Genre

According to Harris M. Berger (1999: 312) heavy metal is “a group of musical genres [-- that --] often employs distorted guitar timbres, individual displays of virtuosity, and complex song forms.” However, like most musical genres, the boundaries of heavy

⁵ See, e.g. “Death Metal/Black Metal” on *AMG All Music Guide*, <http://www.allmusic.com/cg/amg.dll?p=amg&uid=UIDSUB040405161302241951&sql=C384> (accessed May 16, 2004).

metal as a category are quite vague. In his in-depth study on heavy metal, Robert Walser (1993:4) presents “heavy metal” as “a term that is constantly debated and contested, primarily among fans but also in dialogue with musicians, commercial marketing strategists, and outside critics and censors.” It really seems that what is heavy metal for some is not heavy metal for others. This has a lot to do at least with the age and musical preferences of an individual. For instance, most people of my generation (born around the early 1970’s) would consider Deep Purple as a heavy metal band, but in case of Led Zeppelin opinions would vary much more. Representatives of a younger generation of metal fans (followers of bands like Emperor or Dimmu Borgir) would not probably call either of these “heavy metal.” They tend to dismiss Deep Purple or Led Zeppelin (as the recent comments of my undergraduate students have show) as “some old rock acts.” Regarding the effect personal listening habits or musical style preferences have on categorising, Walser (1993:6) quotes Iron Maiden’s lead singer Bruce Dickinson from an interview for *Musician* magazine⁶: “I wouldn’t call UFO a heavy metal band, but if you happen to be a fan of Human League, they probably are. Moreover, if you’re a fan of Motörhead, UFO aren’t heavy metal. [-- heavy metal is] a category.” The categorisation is not axiomatic even for artists themselves – bands that are generally considered heavy metal, may sometimes renounce belonging to that category while others claim to be – and take pride being – the definitive members of the genre. For instance, Led Zeppelin and AC/DC have rejected the term whereas, for example, Judas Priest treasure it. (Walser 1993: 6.)

In answer to the question whether particular bands are, or are not, heavy metal, Brian Russ (2004), a metal fan and the webmaster of a huge heavy metal Internet encyclopaedia *BNR Metal Pages*, states the following:

This is commonly asked about bands such as Korn, Nirvana, Papa Roach, and others, that may not fit the classic metal mold. This is a source of endless debate -- while there are some bands that everyone can agree are metal, there are others that are less clear. Is nu-metal metal? What about glam/hair bands -- are they metal? It's not an easy question to answer. I have tried to include bands that, if not obviously metal, have sufficient metallic qualities or are of interest to metal fans.

⁶ *Musician*, September 1984, p. 53 (Walser 1993: 6).

Another subject of endless dispute among fans and scholars is the question as to whether a particular band is “heavy metal” or “hard rock.” Moore (2004) states that hard rock is “an imprecise term, partly co-extensive with heavy metal.” In fact, in many cases (including this study) those two terms are treated as synonyms. A perfect example on this is presented in the title of a pedagogic article by Dave Whitehill (1989): “A Heavy Metal Primer – The Fundamentals of Hard Rock Technique.”

Heavy metal is often seen as being derived from hard rock as its subgenre (Walser 2004a), but as in almost all genre-labelling we are usually forced to refer to elements outside the music while attempting to establish a difference between heavy metal and hard rock. For example, Moore (2004) basically relies on the lyrics: “The subject matter of the [hard rock] songs emphasizes a misogynistic, macho sexuality and an unfocussed but often environmentally aware liberal politics. Hard rock, however, avoids heavy metal’s leaning towards madness, violence and the occult.” However true this may be, the distinction is made by other than musical terms. Actually, it is quite possible that the distinction cannot be made by musical terms alone. Elsewhere Moore (2001:147-151) has pursued to find some musically significant distinguishing features, asking the profound question “to what extent do the subtle differences between different brands of metal (about which fanatics make great play) equate to differences of musical style [--]?” (ibid: 151). In spite of several important findings, some conclusions seem simplistic and contradictory – perhaps because Moore emphasizes the role of heavy metal as a subgenre of hard rock. For example, Deep Purple is said to be hard rock and not heavy metal, although there is no obvious reason for this. Apparently, this labelling is done on the grounds that hard rock tends to favour an organ instead of a second guitar (ibid: 149). However, the underlying reason as to why the favouring of an organ over a second guitar should be the musical definition for hard rock, appears to be that in Deep Purple there is an organ and not a second guitar (ibid.). So it seems that Moore has first decided that Deep Purple is hard rock and the musical “factor[s] that serve to identify them” (ibid: 148) are then used only to support this pre-determined view. In fact, it is hard to find an unambiguous distinction between hard rock and heavy metal, and many bands (such as Deep Purple) are frequently put under both labels.

Nevertheless, this study follows Moore's suggestion (ibid.) to treat "hard rock" and "heavy metal" as points of a style continuum. However, this is done without trying to point out some significant differentiation. In fact, those terms are very much in parallel: if someone called something hard rock and something heavy metal, the next writer would probably do the exact opposite. Thus, all the music studied here is in some way put under the label "heavy metal." As stated above, the objective of this study is not to define exactly which bands are, or are not, heavy metal, but rather to explore some common melodic-harmonic features of the music that at some point of time has been called heavy metal (together with its main influences and numerous subgenres). Only by doing this we might, some day, be able to tell, what are the basic *musical* features distinguishing heavy metal from other styles. Still, the question remains as to whether this kind of strict categorisation is ever possible or relevant at all. As stated before, the usage of the term (and the terms) seems to be quite a personal matter varying from one individual to another. Here, because of this, the term is understood and used in a very broad sense. Thus, in the text, musical examples from commonly accepted heavy metal canon of the 1970's and 1980's coincide with the pre-heavy music of The Who, Jimi Hendrix and Cream of the late 1960's.

1.2. A Notion on Transcriptions and Reductive Notation

Since the commercially available notations and the guitar tablatures available on the Internet usually have a considerable amount of errors all of the transcriptions here are mine. Because the analyst is forced to make choices on which aspects to include in the transcriptions, they are inevitably subjective representatives of the music (see, e.g. Martin 1996: 5-6). Furthermore, some musical features are impossible to describe with the Western notation system. The insufficiencies of the notation system are more visible when there are features in the music that are alien to Western art music (e.g. blue notes, cf. Titon 1977:154-157). The music is inevitably filtered through the conventions of Western art music and the transcriptions may not carry all the significant features of the music (see, e.g. Seeger 1977: 170). However, Charles Seeger's (1977: 168-171) striving towards an objective description of the music also veers towards results of similar kind – in the end, even the highly objective descriptions (e.g. electronic) will take on fundamentally subjective qualities when they are put

through an individual's (subjective and culturally grounded) interpretation. This problem of subjectivity is not enough to demolish altogether the value of musical transcription in the analysis of musical structures. It is necessary to use language common enough to both musicians and musicologists if we are to mediate any musical features between them. However, due to the necessary selectiveness of the transcription process and the insufficiencies of our notation system, aural analysis of the music should always be combined with analysis on paper.

Furthermore, whenever possible I have used analytic reductions. The most famous scholar using reduction notation was without question Heinrich Schenker (1868-1935) (see, e.g. Schenker 1979). Nevertheless, the reductions applied to the music here are *not* Schenkerian. Here, the reductions are much more used in the spirit of, for example, Leonard B. Meyer (1956: 54, 98) – to reduce a possibly wide musical score to a more simplified form. Meyer's use of reductions is not to promote a musical style as is often done thanks, not so much to Schenker himself, but to his disciples and followers (see, e.g. Covach 1997: 123-124). The reason for using reductions here is simply a matter of convenience – with them I have pointed out certain factors in the music that I think are the most relevant for understanding the musical characteristics under discussion, and have left out the ones that are not so crucial. Of course, this could easily be disputed and regarded as subjectivity, thus I invite the enthusiastic reader to listen to the music while reading this study and to draw conclusions and reductions of their own.

2. The Acoustics of the Loud and Distorted Chords

This chapter deals with some typical chord structures used in heavy metal and their acoustic qualities. Some special attention is given to the so-called “power chord.”

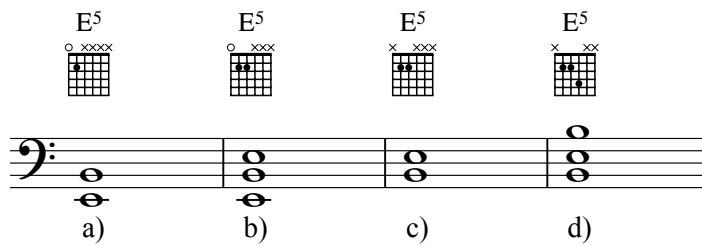
The power chord is an especially normative musical feature for heavy metal. According to Walser (1993: 2) “the power chord is used by all of the bands that are ever called heavy metal and, until heavy metal’s enormous influence on other musical genres in the late 1980s, by comparatively few musicians outside the genre.” Pete Townshend of The Who is often credited with being the first one to use power chords extensively for musical purposes (e.g. Walser 1993: 77; 2004b; Murray 2003; McEvoy 2000), although The Kinks had released the first hit song built around power chords in 1964, “You really got me” (Walser 1993: 9).⁷ However, the origins or the inventors of the *term* are not known. In all probability, music journalists are responsible for the term’s wide acceptance nowadays – by the 1980’s at the very latest it began to appear widely in guitarists’ magazines in parallel with heavy metal’s rise to the popular mainstream.⁸

In this study the term “power chord” refers to a chord that consists only of an interval of the fifth or the fourth with possible octave doublings – as it is generally used by heavy metal musicians (see, e.g. Berger 1999: 313; Whitehill 1989: 122; Marshall 1997: 124, 127). In chord symbols, power chords are indicated with a figure “5” (referring to the interval of the fifth) attached to the letter indicating the chord root – for example, E⁵ consists of only E and B. Power chords have no thirds. In example 2.1, there is an E⁵ power chord in four typical positions for guitar – a, b and c being the most common. The most basic form consists of a perfect fifth, or that with the root doubled in octave (examples 2.1a and 2.1b). Example 2.1c presents the inversion of the first one – for instance, this form is used in the famous riff in Deep Purple’s “Smoke on the water” (1972). The last one (example 2.1d) is the same as the previous with its lowest note doubled in octave – this one is frequently used in more contemporary

⁷ Dave Davies of The Kinks emphasizes the The Kinks’ influence on The Who: “Ray [Davies, the songwriter of The Kinks] has influenced a lot of Townshend’s compositions” (Forte 1977: 53).

⁸ See, e.g. *Guitar Player*, *Guitar World* and *Guitar for the Practicing Musician* of the 1980’s.

metal, e.g. Mercyful Fate’s “Banshee” (1998), but can be found as early as in Jimi Hendrix’s “The wind cries Mary” (1983 [1967]).



Example 2.1. E⁵ power chord in some typical guitar positions.

Although the power chord is apparently made only of a single interval, its sound is remarkably more complex. Acoustically this is due to the heavy distortion and loud volumes that emphasize harmonics and generate resultant tones (see, e.g. Walser 1993: 43). “An effect of both distortion and volume, resultant tones are created by the acoustic combination of two notes” (ibid.). However, before entering further discussion on acoustics, a notion on pitch nomenclature should be made here. As it has been done by Lloyd & Rastall (2004), *italic* letters are used to denote specific pitches in various octaves, and non-italic capital letters denote general pitch classes. In differentiating the various octaves, the Helmholtz system is applied throughout this study: the octaves above the middle C are designated as *c*' (middle C) – *c*'' – *c*''' – etc., and the octaves below are designated as *c* (one below middle C) – *C* – *C*' – *C*'' – etc. (ibid.).

Regarding the acoustics of the power chord (and other chord structures), there are two main phenomena to be covered: 1) the harmonic series, and 2) the combination tones (the difference tones and the summation tones). Every note played on the guitar (or produced by any other instrument) consists not only of the fundamental tone, but of a number of other tones, too. Every note consists of harmonic partials, or components, in frequencies that are the multiples of the fundamental tone (i.e. the first harmonic). “The note *A* sung by a bass, for example, will contain components with frequencies 110, 220, 330, 440, 550, 660 Hz etc.” (Lindley et al. 2003). This concept is known as the harmonic series. Usually, the harmonics gradually weaken in ascending order – the higher numbered a harmonic the weaker the sound (Pierce 1999b: 277). However, the behaviour of the harmonics is quite difficult to predict, especially with distorted sound. For example, there is reason to believe that the human ear can compensate the low-

level sounds (Mathews 1999: 9). Furthermore, it has been shown that different instruments emphasize different harmonics and other features, such as the sound pressure's effect on the sound spectra (see, e.g. Pierce 1999a: 65-66; Rossing 1990: 190, 230-231, 270). Furthermore, different types of distortion and amplifiers give rise to different harmonics. For example, power amplifiers usually emphasize only odd-numbered harmonics while pre-amplifiers treat all harmonics as somewhat equal (see, e.g. Lassfolk 1996). However, as the lowest harmonics are closest to the fundamental frequencies it can be postulated that they form the most audible tones and thus audible harmonics. Although the examples below concentrate on just a few of the first harmonics, they give enough evidence on the complexity of heavy metal guitar sound.

For simplicity, all of the following examples in this chapter are given in proportion to A and its higher and lower octaves. For example, striking the lowest A string on the guitar (110 Hz) will result the harmonics shown in example 2.2 – this example will be significant to the following discussion since the harmonics are given extra strength by distortion. In theory, the number of harmonic partials is infinite, yet the series here is presented only with the first sixteen harmonics.



Example 2.2. The first 16 partials of the harmonic series of A (110 Hz) (an approximate, equal-tempered notation). The frequency of a harmonic is 110 Hz multiplied by the harmonic's number.



Example 2.3. The simplest difference and summation tones of the fifth A-e (a) and the fourth e-a (b).

A combination tone is “a sound that may be heard when two loud musical tones are sounded together but is not present when either of the tones is sounded separately” (Greated 2003b). The discussion on combination tones is easy to start with single frequencies that have no partials sounding with them. Theoretically, if we have frequencies f_1 and f_2 , the simplest resultant combination tones are $f_2 - f_1$ (the difference tone) and $f_1 + f_2$ (the summation tone) (see, e.g. Rossing 1990: 151, 153, Benade 1976: 256-257). For instance, as shown in example 2.3a, the sounding frequencies 110 Hz (f_1) and 165 Hz (f_2) (the justly intoned⁹ equivalents of *A* and *e* in our notational system) result in the combination tones of 55 Hz ($f_2 - f_1$) and 275 Hz ($f_1 + f_2$) (*A'* and *c*[#], respectively). In example 2.3b, similar procedures are applied to the perfect fourth *e-a* (165 Hz and 220 Hz) resulting in the frequencies of 55 Hz (the difference tone) and 385 Hz (the summation tone). As shown in these examples, the same difference tone produced by either forms of the power chord is actually below the register of a standard guitar tuning (also, see Walser 1993: 43).

The previous example is simplistic. In all musical tones, there is always more than just the fundamental harmonic sounding. Furthermore, as the guitar distortion emphasizes upper harmonics, these harmonics are even more relevant to the discussion on heavy metal chords. Thus, further discussion on the fifth *A-e* (or the power chord *A*⁵) calls upon including the upper harmonics of both tones. The next example 2.4 shows *A* ($= f_1$) and *e* ($= f_2$) with their first eight harmonics ($1f - 8f$) and their frequencies. As already stated, all of these frequencies (with many others) are present in the fifth *A-e*. In example 2.4b, there are the harmonic frequencies of both the idealised justly intoned, and those of the equal-tempered *e*.¹⁰

⁹ See, e.g. Lindley 2004.

¹⁰ The equal-tempered frequencies can be found from e.g. the Main Catalogue of DPA Microphones, “How to read microphone specifications” 2004: 73. Note, that the frequency of *G*[#] is erroneously reported as 56 Hz, while it should be 52 Hz.

	$1f_1$	$2f_1$	$3f_1$	$4f_1$	$5f_1$	$6f_1$	$7f_1$	$8f_1$
a)								
	110	220	330	440	550	660	770	880
	$1f_2$	$2f_2$	$3f_2$	$4f_2$	$5f_2$	$6f_2$	$7f_2$	$8f_2$
b)								
Just:	165	330	495	660	825	990	1155	1320
Equal:	164,82	329,64	494,46	659,28	824,10	988,92	1153,74	1318,56

Example 2.4. The first eight harmonics of *A* and *e*.

As can be seen in example 2.4, some of the harmonics of the justly intoned *A* and *e* match perfectly and thus intensify each other (e.g. $3f_1$ and $2f_2$, $6f_1$ and $4f_2$). This amplification happens, of course, only if the two notes are in the same phase – but if they are played together at the same time, they naturally are. For this study, we can safely make that assumption when studying chords and intervals played simultaneously on the guitar.

Furthermore, combination tones are created not only by the fundamentals but by the upper harmonics, too (see, e.g. Benade 1976: 256). These harmonics give rise to difference tones presented in example 2.5.

Combination	Hz (Just)	Hz (Equal)	Notation equivalent
f_2-f_1	55	54,82	A'
$2f_1-f_2$	55	55,18	A'
$2f_2-f_1$	220	219,64	a
$2f_2-2f_1$	110	109,64	A
$3f_1-f_2$	165	165,18	e
$3f_1-2f_2$	0	0,36	(inaudible)
$3f_2-3f_2$	165	164,46	e
$3f_2-2f_1$	275	274,46	$c\#'$
$3f_2-f_1$	385	384,46	g'
$3f_2-4f_1$	55	54,46	A'
f_1+f_2	275	274,82	$c\#'$
$2f_1+f_2$	385	384,82	g'
$2f_1+2f_2$	550	549,64	$c\#''$
$3f_1+2f_2$	660	659,64	e''

Example 2.5. Some combination tones of A and e . The resulting frequencies are given in both justly tempered and equal-tempered system.

These arithmetic operations can be continued indefinitely, but a clear emphasis on the original harmonics of A (and their octave equivalents) can be seen even from these. The simplest combination tones – the first two of which are the most prominent (Rossing 1990: 152) – give frequencies of that equal to A in different octaves. However, the harmonics and their difference tones work exactly like this only in the idealized situation where the interval of the fifth is justly intoned. If the same calculations are made with having an equal tempered fifth as a starting point, none of the harmonics or their combinations match perfectly. If we consider guitar tuning, the real situation is somewhere in between, and dependant on the situation (chord, its positioning, overall tuning). Sometimes it is closer to the just tuning and sometimes to the equal-tempered tuning. For example, if the fifth is equal-tempered, the difference tone $2f_2-f_1$ (219,64 Hz) would be 0,36 Hz lower than the harmonic $2f_1$ (220 Hz). This will result in

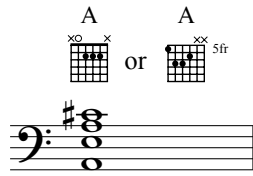
acoustic beating¹¹ between the two. However, the difference of these two frequencies is very small – the beating takes place only once in about every third second (i.e. 0,36 times per second) – and thus, the effect is not very noticeable (see Brian J. C. Moore 2003).

Another matter that can be read in example 2.5 is the frequent occurrence of C#. This means that the major third of the A power chord is present even though it is not actually played. Further studies are needed in what actually sounds, and how strong the different harmonics and combination tones are when played on the guitar. However, there is some evidence that guitar players are aware and even make use of this “virtual” major third. For example, this is clear in Pete Townshend’s following statement: “None of the shapes [i.e. chords] that I play with loud distortion have a 3rd, because you hear the 3rd in the distortion” (Resnicoff 1989: 80). Even though the discussion above is based on an idealised situation where these harmonics are clear, it is evident that the sound of a power chord is richer and more complicated than just the sound of a plain fifth. Townshend continues:

[With a power chord] you’re getting the second- and third-harmonic distortion, so the first note you’re hearing is the 3rd [harmonic], the second note you’re hearing is the 4th [harmonic], and the last note you’re hearing is the 5th [harmonic], so if you *played* the 3rd, you’re going to get a note which is 4th [harmonic] up from *that* [--]. That sound I can’t stand is people playing a complete C chord with fuzz. They’re actually getting something like a C13. (Resnicoff 1989: 80.)

Townshend’s rejection of employing the thirds with distortion can have some explanation in the following. I start by comparing the notes of a major triad with the harmonic components of its single notes. In example 2.6 there is an A-major triad in one of its typical guitar voicing. Example 2.7 shows some of the harmonics of every individual note of example 2.6.

¹¹ See, e.g. Greated 2003a.

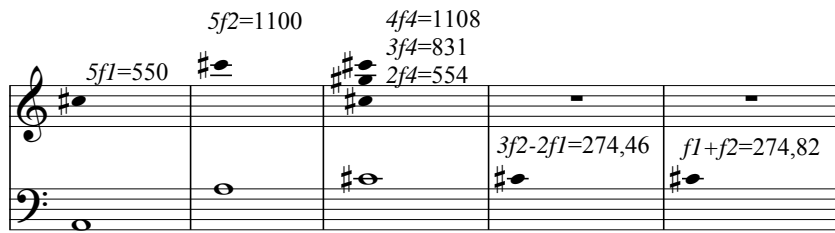


Example 2.6. A-major triad.

	$f1=A$	$f2=e$	$f3=a$	$f4=c\sharp$
Just:	110	165	220	275
Equal:	110	164.82	220	277.00

Example 2.7. Lowest harmonics of A-major triad's single tones. The fundamentals are with open note heads, and the upper harmonics with full.

In example 2.7 the vast number of possible combination tones between the chord tones can easily be seen. Now, all the arithmetic that was used in example 2.5 for calculating combination tones must be applied to these four fundamentals and their harmonics. Justly tempered intervals give no beating (see Appendix I). As can be seen in Appendix I, the combination tones are equal to the harmonic partials of the fundamental tones. The dissonance rises here between upper harmonics that occur in the area of $7f_1$ (770 Hz), $5f_2$, and $3f_4$ (825 Hz both), and $4f_3$ (880 Hz) – the cluster of three minor seconds that presents a dissonance for most of us. Although the justly tempered harmonics can be substantial enough to create a dissonant effect when distorted, the equal-tempered A-major triad raises much more complex sound. As shown in Appendix II, every occurrence of f_4 causes substantial beating with some other harmonic. For example, if only the areas of $c\sharp$, $c\sharp'$, and $g\sharp$ are taken into an account, there are several beating frequencies (example 2.8).



Equal: $f_1=110$ $f_3=220$ $f_4=277.00$

Example 2.8. Some harmonics and combination tones of equal-tempered A, e, c# and a.

As shown in example 2.8, there are several harmonic components with different frequencies around various occurrences of C#. For instance, the fifth harmonic of f_1 ($5f_1 = 550$ Hz) and the second harmonic of f_4 ($2f_4 = 554$ Hz) are both around c#, and cause there a noticeable beating of 4 beats per second. Clashes of different harmonics and combination tones of example 2.8 can be found in the following table (example 2.9).

Notation	Component 1	Component 2	Beats per second
c#'	$5f_1 = 550$ Hz	$2f_4 = 554$ Hz	4.00
c#''	$5f_3 = 1100$ Hz (= $10f_1$)	$4f_4 = 1108$ Hz	8.00
c#	$3f_2 - 2f_1 = 274,46$ Hz	$f_4 = 277$ Hz	2,54
c#	$f_1 + f_2 = 274,82$ Hz	$f_4 = 277$ Hz	2,18

Example 2.9. The table of some beating components in A-major triad.

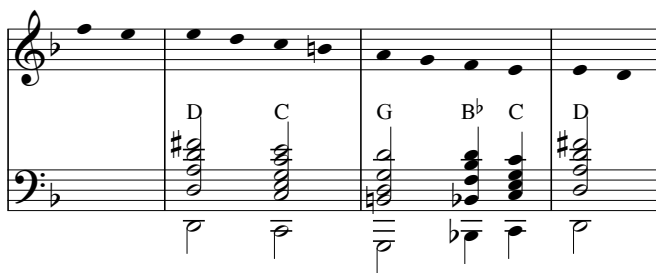
In conclusion, the C# of the played equal-tempered major third is not the same C# that is generated as a harmonic partial of the other original tones. This could be the reason for the rejection of the third by most heavy metal guitarists – the third is considered dissonant because of the beating. However, in earlier heavy metal or in preceding blues-rock the major third has been employed. For instance, the blues-derived opening riff of Cream's "Sunshine of your love" (1968) contains a sequence of altering D-major and C-major triads (with often-omitted fifths) (example 2.10).



Example 2.10. Major triads and melodic motion in riff to Cream: “Sunshine of your love.”

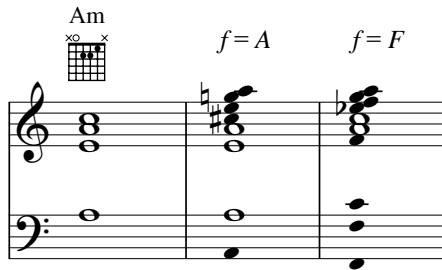
The reason could be that the distortion used by, for example, Eric Clapton of Cream in the late sixties was somewhat milder than that used by, for instance, Judas Priest in the mid eighties. If the distortion is milder, the upper harmonics are not emphasized and the combination tones are not generated in sufficient quantities to cause them to clash too much with the major third – although, aural analysis reveals some amount of “crispness” in the sound.

However, blues-rock guitarists often chose to use triads with major thirds even though those might be seemingly out of mode. This is evident in the previous example 2.10, where the overall tonality and the melodic riff are built around D-minor blues. This is even clearer in Cream’s “White room” (1968) that is clearly built on a D-minor (or, on D-Dorian). Still, the chord on the first (and every) degree is a major triad (example 2.11).



Example 2.11. “White room.”

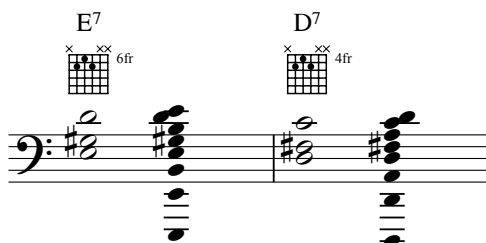
This favouring of a major instead of a minor third can be explained in a similar way as was done with the power chord. Even if the blues-rock guitarists of the late sixties had lesser degree of distortion, they had enough to create prominent harmonics around the major third. With high enough volume the distortion would catalyse the rise of a harmonic series other than that of the chord root (example 2.12).



Example 2.12. A distorted A-minor triad with its resultant harmonics. The original pitches are with open note heads.

A minor triad, when distorted, produces at least two strong harmonic series. By their harmonics and resulting combination tones, the chord root a , its octave doubling a' and the fifth e' emphasize the harmonic series of A (110 Hz). On the other hand, the third $a'-c''$ gives rise to a different harmonic series – the series of F . (For comparison, see Tolonen 1969: 178-179.) This makes the minor triad much more dissonant than any previously mentioned structure. In fact, the occurrences of a minor third with heavily distorted guitar are very rare. In the following, these kinds of acoustically problematic chord structures will be addressed as *vertical dissonances*.

The previous discussion on the acoustics of chord structures could probably be applied to minor seventh of the dominant seventh chord structure, too. This is the structure used frequently in blues-derived rock. The structure of the dominant seventh chord is straight from the harmonic series of the fundamental – dependant on voicing, at least the fourth, fifth and the seventh harmonics are present. This is the voicing of the next example “Politician” (1968, again from Cream), presents the dominant seventh chords on bars 9-10 (example 2.13).



Example 2.13. Dominant seventh chords with implied harmonics in Cream: “Politician.”

In the following chapters those chord structures, which abide by the lowest partials of the harmonic series of the fundamental tone, will be addressed as *Acoustic chords*. In the following analyses, a special symbol is used to identify them – throughout this study, a tilde (~) is placed above an analytical symbol. For instance, the D-major chord in “White room” could be labelled with \tilde{I} . This special labelling has been used because, as has been shown here, these kinds of chords, which seem to be out of key or mode are quite frequently used in heavy metal. Yet, they have not been receiving enough scholarly attention in music analysis.

The discussion on the acoustic features of heavy metal chords has been theoretical here. However, I believe that the ideas presented can offer a fruitful starting point for further studies.

3. The Problem with the Chord Roots of Dyads

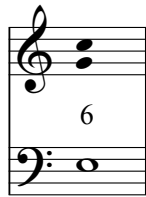
Another issue that has not been studied enough is the subject of chord roots and how they relate to the bass note (i.e. the lowest sounding note). In heavy metal they are usually the same. This apparently trivial question is important because since Jean-Philippe Rameau's *Traité de l'harmonie* (1971 [1722]) it has been a common practise to think in terms of chord inversions. However, as will be shown below, in heavy metal practises chord inversions do not play that significant a role. Furthermore, heavy metal chord constructing seems to be more similar to the intervallic practises of *figured bass*.

3.1. The Chord of the Open Sixth

Renaissance theorists like Gioseffo Zarlino thought in terms of intervals (Webster 2004). For example, in his *The Art of Counterpoint* (1968 [1558]) Zarlino describes how harmony is constructed of *intervals* without once referring to *chords*. In the Baroque era, Zarlino's views on harmonic foundations gained importance in the practise of *basso continuo*. In continuo playing, or writing, chords played an important role – but unlike today's common way of thinking, the chords were thought as various intervals built on the bass as designated by the figures above it (see, e.g. Williams & Ledbetter 2004). Rameau's innovation was to classify chords by their constituents in a way that gave an important role to the imaginary bass line called the *fundamental bass*.¹² Basically, the concept of fundamental bass means that detection and determining of a chord's root is made by means of “restoring” a chord to a stack of thirds (see Rameau 1971: 40). To accomplish this, the chord's constituents are rotated as much as needed. For example, the notes of a chord E-G-C would be rotated to C-E-G. This idea gained wide acceptance because it diminished the enormous amount of different chord classes to a much lesser number. Furthermore, Rameau's innovation was important to harmonic thinking because now the E-G-C belongs to the “family” of C-chords, when before Rameau it had belonged to E-chords (example 3.1). In other words, with *figured bass* of continuo the note determining the chord is the bass note,

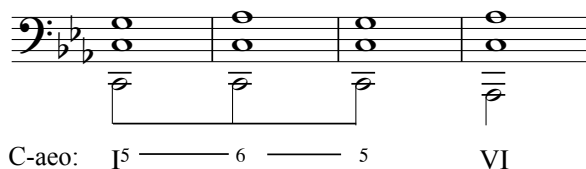
¹² See, e.g. “Fundamental bass” 2004.

whereas in Rameau’s concept the chord-defining note is the lowest note of stacked thirds (see, e.g. Riemann 1977: 220).



Example 3.1. An E6-chord with figured bass and the implied harmonies on the treble clef.

In most heavy metal there is such a strong emphasis on the bass notes that the analysis should also rise from them. This is especially true with dyads. I will clarify this with the following examples presenting an open-minor-sixth dyad in two different power chord surroundings. These minor-sixth dyads often come between power chords, and (being acoustically more unstable than power chords) are used in various kinds of passing motions. Like power chords these sixths are quite rich in sound – due to their distorted sound. Hence, in this study any harmonic structure played by guitar is addressed as “chord,” be it a dyad, triad, tetrad, or a more complex form. The verse of Accept’s “Metal Heart” (1985) starts with the chord progression shown in example 3.2.



Example 3.2. Chord progression in the verse of Accept: “Metal Heart.”

The guitar applies power chords and open-sixth chords in C-Aeolian mode (C-aeo). When the guitar moves from the first C⁵ power chord to the sixth *c-a^b*, there is no change in chord root. That is to say that in the first three bars the harmony is on the first degree chord – only after that it moves to VI. This is due to the bass remaining in C and the overall heavy emphasis on C – for example, by doubling in different octaves. Only the second occurrence of *c-a^b* coincides with the chord root moving from C to A^b – with help from the bass. Then all the parts (the guitar and the bass) work together for

the harmonic series of A^b. In that sense, the sixth in the mm. 2 is quite dissonant. There are more differing harmonic overtone structures sounding simultaneously – naturally, that means more complexity and more beating, too.

Although this example is easy to explain as a passing note in the top voice, it is noteworthy that in this case the chord of the open sixth (in mm. 2) belongs to a different category than the major third (in mm. 4). Unlike Rameau would say, the chord C-A^b belongs here to the same chord category as C-G – that of the I degree chords – whereas the A^b-C belongs to the VI degree chords. Actually, this is quite near to Riemann’s (1961: 527-528) *Leittonwechselklang* that refers to replacing a chord’s fifth with its upper, or a chord root with its lower leading tone. I suggest verifying this analysis by listening to the chord progression, and thinking at which point of time the change of chord root can be perceived.

In Judas Priest’s “The Sentinel” (1984) the open minor sixth is present in a different passing motion (example 3.3). The example is of the section leading to the chorus, and is in A-Aeolian mode.

a)

A-aeo: IV⁵ V⁽⁵⁾⁶ VI⁵ VII⁵ I⁵

b)

A-aeo: IV⁵ V⁽⁵⁾⁶ VI⁵ VII⁵ I⁵

Example 3.3. The chords and the vocal melody to Judas Priest’s “The Sentinel” including two occurrences of an open minor sixth. With melodic tones I use Schenkerian numbers with carets (^) to denote the relation of a tone to the tonal centre (see, e.g. Schenker 1979: 13). The numbers between the staves denote the interval between the bass and the melody – according to the customs of traditional counterpoint (see Mann 1971: 29).

According to Rameau's "stacked thirds" theory, the second chord (of the open sixth) should be analyzed as a III degree triad in its first inversion. However, this proves to be problematic. The first and the most important line that strikes the ear is the lowest: D-E-F-G-A. In this case, too, the bass line is doubled several times in several octaves, leaving the second chord's sixth with little influence on chord-root detection. The sixth is rather a more dissonant variation of the more common fifth. Moreover, the vocal melodic line in example 3.3a is on $\hat{2}$ forming the fifth with the base and leaving the sixth even more isolated. Example 3.3b offers an interesting variation. Now, the vocal melody is with the sixth and remains on $\hat{3}$ until forming a blues-like melodic cadence $\hat{3}-\hat{1}$ to the tonic (cf. Martin 1996: 28). Still, the C does not gain enough strength to act as a chord root. In light of this example, it seems that the melodic line has two possibilities concerning the sixth. It can be ignored by following the harmonics of the fundamental (as in example 3.3a), thus the sixth is left as a colouring dissonance, or, its harmonic colour can be emphasized as was shown in example 3.3b.

If a larger scale analysis is applied to "The Sentinel," the sixth's note C would be a preparation of the next chord's fifth. Still, the open-sixth chord is common enough in heavy metal to deserve a symbol of its own. The symbol $V^{(5)6}$ I have chosen to use here calls for an explanation. The chord symbols used in guitar magazines and commercial note books have typically two ways of handling the minor sixth. It is either marked as an inversion (the sixth in "The Sentinel" would be C/E), or as an augmented fifth ($E^{+5(\text{no } 3\text{rd})}$). For the reasons discussed above, a symbol implicating an inversion is out of the question, and calling a minor sixth an "augmented fifth" is modally and tonally unacceptable. Moreover, having discussed the subject with several heavy metal guitarists, many spoke specifically of "the chord of the minor sixth" when referring to these kinds of chords. Thus, the first natural choice would have been a single number "6." In the analyses made here, the numbers are interpreted according to the mode in use. Very similar to figured bass numbering, if we had an A-minor mode, the number 6 on a bass note E would give us an E and a C (and a G in figured bass). This single 6 would have made a suitable parallel to power chords label – 5 for "fifth", 6 for "sixth." Indeed, they seem to be parallel, at least where the guitar's instrumental techniques are in question – it is very easy to change a fifth into a minor sixth by moving one finger only. However, the number six carries at least two strong connotations. In traditional

power chord. In that case, the harmonic series of the upper tone is an overriding element in perception. This is the case of the guitar riff in Deep Purple’s “Smoke on the Water” (1972). Deep Purple’s guitar player Ritchie Blackmore often applies these kinds of power chords particularly in riff-type guitar patterns. In the cases like this the bass usually works as a pedal point (example 3.5).

The image shows a musical score for the bass line of "Smoke on the Water". The staff is in bass clef with a key signature of one flat (B-flat). Above the staff, there are labels for guitar power chords: I⁵, III⁵, IV⁵, I⁵, III⁵, bV⁵, IV⁵, I⁵, III⁵, IV⁵, III⁵, I⁵. Below the staff, the bass line is written with a constant G note (pedal point) and some moving notes. The label "G-aeo:" is on the left, and "I", "IV", "III", "I" are placed below the staff to indicate the degrees of the chords.

Example 3.5. The riff to “Smoke on the water.” This reduction shows the guitar and the bass parts.

Actually, the guitar’s power chords can be heard as a single melodic line, the sound of which is strengthened with a perfect fourth below. The pedal point in the bass establishes the tonal centre effectively and joins only the last four power chords.

However, sometimes the tonal environment and voice leading practises call for another kind of interpretation. When the perfect fourth is in relation to the bass (i.e. the fourth’s lower note is on the bass), it is usually considered as a “dissonance” (Salmenhaara 1968: 25) or at least “unstable” (Drabkin 2003). In any case, it has to resolve to a third or a fifth. This kind of usage of the perfect fourth can be found, for example, in the songs of Judas Priest. For instance, “Devil’s Child” (1982) has an E-Dorian I⁵-IV⁴⁻³-I⁵. This suspended fourth is also in Ozzy Osbourne’s “Crazy Train” (1981) (example 3.6).

The image shows a musical score for the bass line of "Crazy Train". The staff is in bass clef with a key signature of two sharps (D major). Above the staff, there are labels for guitar power chords: I³, V⁵, I⁴ — (3). Below the staff, the bass line is written with a constant A note (pedal point) and some moving notes. The label "A-ion:" is on the left, and "I", "I — 7 — 6 — 5" are placed below the staff to indicate the degrees and passing notes.

Example 3.6. Reduced riff to the verse of Ozzy Osbourne: “Crazy Train” with the guitar and the bass parts included.

The guitar’s dyads are built on the bass’ pedal point on the I degree. As it is marked in the analysis, the bass is embellished with passing notes (8)-7-6-5. The perfect fourth’s

resolution on the first degree sounds just like a classic suspension-resolution I^{4-3} . However, the most intriguing feature in this example is that the third of the last chord (i.e. the resolution tone) is not actually played – in the analysis it is therefore put in parenthesis: (3). Still, it can be heard quite clearly. There are two main reasons for this, the first being tied to the tonal expectations. The ear of the average Western listener is so well trained in major/minor tonal music that they expect to hear the fourth going to the third. The fact that this kind of fourth on the I degree chord moves to a more stable chord on the same degree is enough to create expectations for hearing a C^\sharp . Actually, I have heard many guitarists playing out the originally missing C^\sharp – thus, it appears that the C^\sharp is relevant to them. Moreover, the C^\sharp is acoustically present in the chord's harmonics – as presented in examples 2.4 and 2.5 of the previous chapter. Also, note Pete Townshend's statement cited above: "I hear the third in distortion."

Thus, the perception of this musical phenomenon is affected by both culturally-based expectations and the chord's acoustic structure. It seems that the role of tonal expectations in the perception of the fourth are enforced when we have a minor-type mode – as in "Smoke on the Water" (example 3.5 above). In "Smoke on the Water" the mode is a minor-related Aeolian, whereas "Crazy Train" is in Ionian (i.e. common major mode). The fourth in the bass does not inflict the need for resolution in "Smoke on the Water" – at least not that strong. On the contrary, it is quite difficult to hear a 4-3 resolution between the IV^5 and the I^5 . In that case, the modal/tonal context (minor third in the mode) and chord structure's acoustics (major third as a harmonic partial) are conflicted. My ear decides for the mode here. Moreover, arithmetically the major third seems to be weaker in the interval of the fourth than in the fifth.

Interpreting "Crazy Train's" fourth as a suspension is further supported by the fact that the "fourth against the bass" is on the strong beat and its resolution on the weak, whereas in "Smoke" the situation is reversed: the fourth against the bass (IV^5) is on a weak beat and the following I^5 is on the strong. Furthermore, the role of the bass is different in these two riffs. In "Crazy Train" the bass acts as a pedal point only for the first bar's V^5 . It is really not a proper pedal point at all – the chords V^5 and I^{4-3} are likely to be perceived as passing motions against the bass. On the contrary, the pedal

point that carries almost throughout the whole riff in “Smoke on the Water” is much stronger – it is long enough and has more changing dissonant motion above it.

In using the fourth there is still one point to make – a point that is pertinent to voice leading practises. The “upper note as a root” interpretation of “Smoke on the Water” is enforced by the fact that the interval harmonizing the riff’s melody does not change. Those kinds of unchanging intervals tend to melt into the main line, thus becoming a part of its sound. In those cases the melody and its harmonizing interval are likely to be perceived as a whole, or, as a one-note melody. This is not the case with diatonic intervals that act more under the traditional voice leading, and have more independence. For example, the harmonizing of “Crazy Train’s” riff with various diatonic intervals creates a need for resolutions within the riff more than the harmonizing with chromatic parallel intervals would.

4. Scales, Modes and Voice Leading in Heavy Metal

In the traditional Western art music, at least since the early eighteenth century (see Riemann 1977: 162-163), there have been only two modes – the major and the minor (see, e.g. Harrison 1994: 17; Salmenhaara 1980: 197). However, the scales, or modes, used in heavy metal vary much more and can be traced to at least three primary sources – 1) the blues-derived pentatonicism, 2) the so-called church modes and, 3) the Western major/minor tonal influences.

4.1. Pentatonic and Blues Scales

As heavy metal is a subgenre of rock, its roots are in rock 'n' roll. Rock 'n' roll has its origins in rhythm & blues, and rhythm & blues in the blues (see, e.g. Wagner: 2003: 353). “[--] heavy metal guitarists who did not study the blues directly learned secondhand, from the cover versions of Eric Clapton and Jimmy Page or the most conspicuous link between heavy metal and blues and r&b, Jimi Hendrix” (Walser 1993: 58). Hence, it follows that in heavy metal there are elements that originate from the blues. One such a feature is the use of pentatonic scales. The blues-derived pentatonicism is an important feature especially in early heavy metal, but some of its influence has remained in later metal, too. As an early example, the vocal melody in Jimi Hendrix’s “Purple Haze” (1967) is built on E-minor pentatonic scale degrees, as are the chord roots (I-III-IV), too (example 4.1).

The image shows a musical score for the song "Purple Haze" by Jimi Hendrix. It features a vocal melody in the treble clef and a bass line in the bass clef. The key signature has one sharp (F#). The melody consists of the notes E4, G4, A4, B4, D5. The bass line consists of the notes E3, G3, A3, B3, D4. The chords are labeled as E7#9, G, and A.

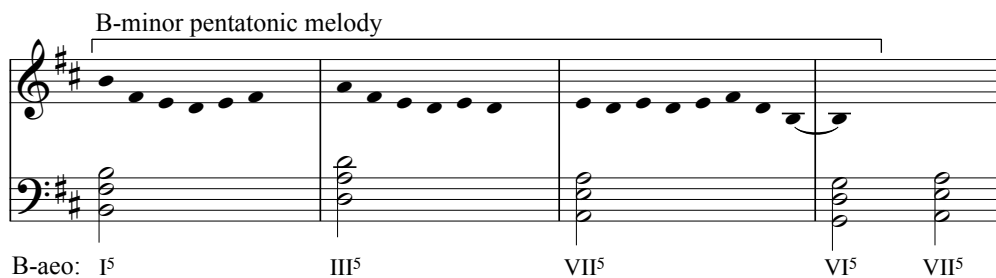
Example 4.1. “Purple Haze.”

Another early example is the vocal melody in Deep Purple’s “Speed King” (1970) that is basically plain G-minor pentatonic (example 4.2).



Example 4.2. Overall melodic line in the verse of “Speed King.”

Pentatonic vocal melodies have been an important part of Deep Purple’s later music, too. In “Knocking at Your Backdoor” (1984) the vocal melody is clearly pentatonic. However, with the chords the overall melodic-harmonic environment is more near to a modal Aeolian scale (example 4.3). This is one example of how pentatonic melodies can occur with harmonic environments that are derived from other sources (as will be discussed in later parts of this chapter).



Example 4.3. Overall melody and harmony in the first four bars of the verse of “Knocking at Your Backdoor.”

Pentatonic influences can also be detected in the choices of chord degrees, and especially their roots. The chords in “Knocking at Your Backdoor” are quite near to the following progression, the variations of which have been widely used in heavy metal from the seventies (e.g. Deep Purple: “Highway Star” [1972]) through the eighties (e.g. Iron Maiden: “2 Minutes to Midnight” [1984]). The next example is from Iron Maiden’s “Running Free” (1980) (example 4.4).

blues, jazz and rock under a single label “Afro-American music,” John Shepherd (1991: 129, 131) states that “many Afro-American melodic lines seem to be pentatonic.” While this might be true in general, it is certainly a simplistic view regarding heavy metal.

4.2. Modal Scales and the Modal System

If we put aside those readings of the term “mode” that are applied to rhythms and intervals, the term “has always been used to designate classes of melodies, and since the 20th century to designate certain kinds of norm or model for composition or improvisation as well” (see, “Mode” 2003). Despite that “mode” is a concept in the history and theory of European music it is also a modern musicological concept that has been applied to non-Western music since the late 18th century (Powers & Wiering 2004a, Powers & Widdness 2004; also, see Pennanen 1999: 42-44). The modal concept has been applied to the study of Anglo-American folksongs, too (see, e.g. Powers & Cowdery 2004). In addition, the composers of the Western major/minor tonal era (e.g. Beethoven, Schumann, Chopin, Liszt, Bartok, and Debussy) have occasionally used the modal scales of earlier periods – derived from various folk music traditions or from the old church modes (see, e.g. Porter 2004).

With no doubt Anglo-American folk music traditions have been significant in the formation of other popular styles such as rock. This influence can be traced back at least to the 17th or 18th centuries (see, e.g. van der Merwe 1989: 16-17), but I restrict the following to more recent influences. Some modal qualities of heavy metal come directly from the folk music of the 1960’s. For example, Jimi Hendrix’s “All Along the Watchtower” (1983 [1968]) is originally written and performed by Bob Dylan (*John Wesley Harding* 1967), and Judas Priest made a cover version of Joan Baez’s “Diamonds and Rust” (*Diamonds & Rust* 1975) for their album *Sin After Sin* (1977). Both Dylan and Baez derived much of their music from the traditional Anglo-American folksong. Furthermore, both of these songs have melodic and harmonic qualities that can be described easily as “modal” (see the analysis of “All Along the Watchtower” below).

If we can speak about folksongs as “modal” (as in Powers & Cowdery 2004) we can also apply the same term to heavy metal. Scales resembling the church modes had been used by e.g. The Beatles, but since the 1970’s many guitar players have definitively become familiar with modal scales (i.e. church modes) through various music theory books (see, e.g. Walser 1993: 65-66). Actually, it seems that the melodies and harmonies of heavy metal are more often built according the modal scales than, for example, the major/minor system of Western art music. This can be seen, for example, in the importance of the chord progressions that move in thirds and seconds, and in the extended usage of the “flattened” seventh degree (see, e.g. Moore 1995). Also, the musicians have explicitly stated using modal scales as a compositional or improvisational starting point (e.g. Whitehill 1989). These facts support the use of a modal system in the analysis of heavy metal.

The modal system used here has been introduced by Allan Moore (1992; 1995; 2001). In this system the chord degrees relate to a modal scale, not to the traditional major or minor scales. In this study the terms “mode” and “modal” are used to designate scale types and not “melodic motifs” or “patterns” as it is sometimes done (see, e.g. Powers & Cowdery 2004). The names used here for the modes are those originally derived from the theories of the Ancient Greeks for the use of Gregorian plainchant and Renaissance polyphony. The scale types are mostly the same that were introduced in the 16th century by e.g. Heinrich Glarean (1488-1563) and Gioseffo Zarlino (1517-1590) (Powers & Wiering 2004b). Thus, here the modes refer to seven note scales (and here, to their equal-tempered equivalents), where the tones (t) and semitones (s) are distributed as follows:

Lydian (abbr. lyd):	t – t – t – s – t – t – s,
Ionian (ion):	t – t – s – t – t – t – s,
Mixolydian (mix):	t – t – s – t – t – s – t,
Dorian (dor) :	t – s – t – t – t – s – t,
Aeolian (aeo) :	t – s – t – t – s – t – t,
Phrygian (phr):	s – t – t – t – s – t – t
Locrian (loc) :	s – t – t – s – t – t – t.

The first six of these were used in the music of the medieval and Renaissance eras. Their names also originate from those times. The difference between modern usage and the medieval is that here the modes can be transposed to any tone, whereas medieval modes were usually tied to certain notes (e.g. Aeolian is an A-mode, Phrygian is an E-mode etc.; see, e.g. Jeppesen 1975). The seventh mode, Locrian, was acknowledged by the Renaissance theorists, too (e.g. Zarlino 1968: 43). However, at that time it was basically nonexistent in practise because of the diminished fifth between its root and the fifth. However, “the alternation between E in the bass and the B^b power chord seems unusually common in trash metal. In Renaissance and baroque music, this relationship connoted the works of the devil [--]” (Moore 2001: 179n21). This interval addressed as the “Devil in music” back then has been widely used at least since the late 1980’s speed metal (e.g. Metallica’s *And Justice for All...*), but already in the early 1970’s by Black Sabbath (e.g. the albums *Black Sabbath*, and *Paranoid*, both 1970).

In the modal system the chords are built of the modal scale-steps, just like in traditional chord constructing. For instance, the next example shows the chords that are constructed of C-Mixolydian scale-steps (example 4.6). The symbols that denote the “key” in the beginning of the analysis are mine (e.g. “C-mix” means that the following chords are analyzed in C-Mixolydian mode).


C Dm Em^{b5} F Gm Am B^b

C-mix: I II III IV V VI VII

Example 4.6. The triads of C-Mixolydian mode.

The basic advantage of Moore’s system is that it makes harmony analysis much simpler and diminishes the need for chromatic symbols for “root altered” harmonies. This is especially important if we do not want to treat those chord degrees that differ from those of the traditional major/minor tonal system as some sort of deviations (this has been discussed in length by Moore 1992). Using an analytical method that has the major/minor tonal music as a starting point can lead us to see the major/minor tonal features as “normal” or “natural,” and anything that differs from those features as

“deviant” (see, e.g. Everett’s [2000] Schenkerian analyses of rock music). For instance, in much rock music the Mixolydian seventh degree is far more prevalent than the Ionian (i.e. major) seventh degree (see Moore 1995). The analytic labelling according to a mode makes the analysis simpler. For example, if we analyze the popular Aeolian chord progression VI-VII-I with the principles of traditional harmony analysis, the results look quite strange and hardly do justice to the music. The next example shows Jimi Hendrix’s “All Along the Watchtower” analyzed with Erkki Salmenhaara’s (1968: 61) principles and with the modal system (example 4.7). According to Salmenhaara, and Walter Piston (1962: 33) the analysis is made in harmonic minor. In the light of this example it is evident that the modal system makes the analysis more compact.

Bm	A	G	A	Bm	A	G	A	Bm
								
B-minor:	VI	V ^{7b3} ₍₁₎	I					
B-aeo:	VI	VII	I					

Example 4.7. The chord progression to Jimi Hendrix’s “All Along the Watchtower” analyzed according to the traditional harmony analysis and modal system.

Note, that for Salmenhaara the A-major chord is an altered chord, thus the additional figures and chromatic markings. On the other hand if the song is analyzed in Aeolian mode there are no altered chords. The chord progression in question is in fact so common that is hard *not* to find it in the music analyzed here – for instance, it can be found in almost every Iron Maiden song (see, Iron Maiden 1980, 1981, 1983, 1984, and 1986).

While Moore’s theory is sound it could have been taken further. In practise heavy metal chords do not follow one single mode, and thus, we still have to use chromatic altering to achieve the correct structure. For instance, Moore (2001: 55) analyzes Jimi Hendrix’s “Hey Joe” as an Aeolian VI-III-VII-IV^{#3}-I^{#3}. The major thirds that do not abide by the mode have to be written as an altered harmony. Apparently Moore has not

taken in to an account one important feature of rock – that the vertical structure of a chord is often more important than whether a chord abides by a certain mode. This will be discussed in detail in Chapter 5.

A further note regarding “Purple Haze” must be made here. In my opinion, it is as relevant to analyze it either as using a pentatonic or as using a Dorian mode. The Dorian interpretation could face criticism on the grounds that all the notes of the Dorian are not present. However, the problem is similar with the pentatonic interpretation, too. To be accurate, the melody that contains only of three notes D-E-G is rather a *triatonic* than a pentatonic one. If the chord roots are taken into an account, we would have a four-note scale D-E-G-A. Furthermore, if the thirds of the G-major and A-major are added, the result is close to E-Dorian – with only the F[#] missing. Both of these interpretations, whether Dorian or pentatonic, include notes by implication i.e. “filling in the missing notes” (see Pennanen 1999: 40-43). At least for the purpose this study, however, the advantages of the modal system outweigh its problems.

4.3. Major/Minor Tonal Influences in Heavy Metal

Although, the modal scales seem to be particularly important for heavy metal harmony, the influences of classical major/minor tonal music are a prominent part of heavy metal vocabulary. Heavy metal has taken influences from classical music at least since the early seventies. An easy way of detecting this is to note some quotations of classical repertoire in heavy metal context. For example, Deep Purple’s organ player Jon Lord quotes Beethoven’s *Für Elise* in the song “Speed King” (1970). Lord was classically trained, and even composed a lengthy piece called *A Concerto for Group and Orchestra* (1970) incorporating a full symphonic orchestra into the band. In fact, some other members of Deep Purple also had at least some classical training. The guitarist Ritchie Blackmore took some lessons in classical guitar before Deep Purple, and took up the cello in the late seventies (Webb 1984: 54; Rosen 1984: 59). Blackmore frequently uses melodic figures derived from Baroque composers in his guitar solos and riffs – this has been discussed in length by Robert Walser (1993: 57-107; 1992), so I will restrict myself to a single example, “Highway Star” from *Machinehead* (1972).

Blackmore comments the solo of “Highway Star,” “it’s just arpeggios based on Bach” (Rosen 1984: 62). Indeed, the guitar solo resembles the characteristic Baroque style: the fast and repeated sixteenth note pattern on the chord progression following the circle of fifths (example 4.8).¹⁴

The image displays four staves of musical notation, each representing a different chord in a progression. The chords are labeled as D⁸, G⁸, C⁸, and A⁸. Each staff contains a fast, repeated sixteenth-note arpeggiated pattern. The first three staves (D⁸, G⁸, and C⁸) show a consistent rhythmic pattern of sixteenth notes. The fourth staff (A⁸) shows a more complex pattern with some chromatic movement in the notes, including sharps and naturals.

Example 4.8. Excerpt from the guitar solo of “Highway Star.” Only the first guitar track is included in this transcription. The chord symbols with the figure “8” denote that the accompaniment includes only the single note (possibly) doubled in octaves.

In Jon Lord’s organ solo for the same song, these arpeggios have similar kinds of influences, now with a chromatically descending bass line that also was favoured by Baroque composers (see, e.g. de la Motte 1987: 74). Example 4.9 is from Deep Purple’s live album *Made in Japan* (1972).

¹⁴ Walser (1993: 65) has the same example with the guitar harmonized in parallel thirds – a note must be made here that in Walser’s transcription there seems to be some mistakes on the descending chromatic line of the last two bars.

Example 4.9. Excerpt of Jon Lord's organ solo for "Highway Star."

In fact, many heavy metal musicians of the seventies and eighties were either trained in classical music or self-learned in the ways of traditional theory of harmonies and melodies.

Throughout the 1970s, guitarists continued their experimentation with fusions of rock and classical music. Just as jazz musicians had done in the late 1940s, some rock guitarists turned to classical music theory for new musical resources. (Walser 1993: 65.)

This influence is evident in the works of musicians of the 1980's – the classical influences are not anymore quotations or borrowed patterns, rather the classical vocabulary is incorporated in heavy metal style. Guitar players such as Randy Rhoads and Yngwie Malmsten made the classical influenced repertoire a prominent part of heavy metal vocabulary (see, e.g. Walser 1993: 78-102). They had both studied classical music from an early age (ibid. 78, 93), and when turning to heavy metal brought the major/minor tonal practises with them. It is safe to conclude, that they both were well-accomplished in classical music theory. One example of this can be seen in Rhoads's notational sketches on the album cover of Ozzy Osbourne's *Randy Rhoads Tribute* (1987). The sketches include seventh chord arpeggios for all seven modes in the key of C[#]-major, including their primary chords (II^m7, V7 and I^{maj}7 – as they typically are in jazz). Furthermore, the chord substitutions seem to follow quite normative major/minor tonal conventions (e.g. I can be substituted with VI).

In Ozzy Osbourne’s “Mr. Crowley” (composed by Rhoads) there is a very Baroque-like sequence technique used for the introduction (see Walser 1993: 79). Furthermore, the intro is played on the synthesizer using a sound resembling a pipe organ. Note that the chord progression and the bass are very much like that of the traditional *basso continuo* – for example, the bass fills in the gaps between the chord roots with stepwise passing movements (example 4.10).

The musical score for the introduction of "Mr. Crowley" is presented in two systems. The first system shows a chord progression of Dm, Am, F, and C. The second system shows a chord progression of Am, Em, Asus4, and A. The bass line features stepwise passing movements between chord roots.

Chord progressions and bass line notes (from left to right):

- System 1: Dm (D-minor: I), Am (V_b), F (III (A-minor: VI)), C (V_bVII III)
- System 2: Am (V_b I), Em (II V_b), Asus4 (V_b VI), A (IV II), A (V₄—3)

Example 4.10. The intro from “Mr. Crowley.”

For solo parts of “Mr. Crowley” the chord progression of the intro is modified into a full circle of fifths in D-minor. “Until classically influenced heavy metal, such cyclical progressions were unusual in rock music, which had been fundamentally blues-based” (Walser 1993: 80). In another Ozzy Osbourne song, “Crazy Train” (1981), Rhoads uses yet another clearly classically influenced compositional solution. The key changes between the introduction, verse and the chorus make use of the relative minor and major keys (example 4.11; the song is analyzed in detail in Lilja 2002). The introduction (mm. 1-7) is grounded on F[#]-minor, or better, F[#]-Aeolian because of the usage of the extremely common Aeolian cadence VI-VII-I. On the other hand, the verse (starting in mm. 9) is in A-major (e.g. A-Ionian). The cadence in mm. 8 acts as a

transition between the two keys – it is first interpreted as an Aeolian cadence as before, but this interpretation is altered as soon as the A-major riff starts. After that, the two power chords of mm. 8 are perceived with the riff’s first chord as a normative major/minor tonal cadence IV-V-I.

F#-minor/
F#-aeo: I III VII I VI VII

I III VII I

F#-minor/
F#-aeo: VI VII
A-major/
A-ion: IV V I I-7-6-5 I I-7-6-5

I³ V⁵ I⁴—(3) I³ V⁵ I⁴—(3)

Example 4.11. Ozzy Osbourne: “Crazy Train,” the guitar and the bass parts for introduction and the beginning of the verse.

In “Revelation (Mother Earth)” (1981) Rhoads makes use of a parallel major and minor (example 4.12). Also, the instrumentation is classically influenced – there are at least acoustic guitars (both metal and nylon string), flute, string quartet, and tubular bells.

Em B7 Em B7 Em G D B7 B7/F# Em/B B7add11 B7 Em
 E-minor: I V I V I aeoIII aeoVII V7

4	_____	3
8	_____	7
6	_____	5
4	_____	3

 I

E E B^b B^{b9} B C A B C A C⁵ B⁵ Em
 E-major: I locV ⁹/₇E-minorṼ ṼĨ ṼIṼ ṼṼ ṼVĨ ṼIṼ VI⁵ V⁵ I

Example 4.12. Harmonies for “Revelation.” Vocal part is on the upper staff.

The verses of the song (mm. 1-10) are played with the soft sounds of acoustic guitars, a string quartet, and the flute. The overall mode is classically influenced major/minor tonal harmonic minor in the key of E – with two modal degrees from E-Aeolian. The cadence in mm. 9-10 includes interesting suspensions. For example, there are two suspended fourths that resolve separately. From mm. 11 the instrumentation changes to the distorted electric guitars. In addition, the key is changed – although there is a Locrian V degree creating tonal suspension, the overall feel of the key is E-major. This change of key is actually quite dramatic. It is noteworthy that when the guitar changes to distortion, the chord structures in use change accordingly – to the Acoustic chords discussed in the previous chapter. There are no minor triads until the return to the acoustic-based ensemble in mm. 18.

In Rhoads’s own words:

“Revelation” and “Mr. Crowley” are my favourite cuts on the first LP because both of them have a heavy classical influence. I think the relationship between heavy metal and classical music is great. (Obrecht 1984: 176.)

Rhoads was not the only or the first one to make heavy use of classical music, but certainly he was one of the most influential players/composers in that field for future generations:

Rhoads's interest in music theory was symptomatic of the increasing classical influence on heavy metal, but his success also helped promote classical study among metal guitarists. Winner of Guitar Player's Best New Talent award in 1981, Rhoads brought to heavy metal guitar a new level of discipline and consistency, derived from classical models. [--] Rhoads accomplishments also contributed to the growing tendency among guitarists to regard their virtuosic solos in terms of a division of labor long accepted in classical music, as opportunities for thoughtful composition and skilful execution rather than spontaneous improvisation. (Walser 1993: 84.)

In fact, numerous other heavy metal guitarists have expressed their appropriations to classical music – starting from Jimi Hendrix (Burks 1984: 22), Jimmy Page of Led Zeppelin (Rosen 1977a: 44, 50), and John Paul Jones, the bass and keyboard player of the same band (Rosen 1977b: 104), to K.K. Downing and Glenn Tipton, the guitarists of Judas Priest (Varney 1984: 132).

4.4. Mixed Scalar Contents and Voice leading Derived from Different Traditions

Often in heavy metal the major/minor tonal, the modal, and the pentatonic features act in parallel. For example, as briefly mentioned in the previous chapter, Judas Priest's modally constructed harmony in "The Sentinel" includes a pentatonic-like melodic motion from the minor third degree to the first – such motions are quite dogmatic for blues melodies (see, Titon 1977: 155). However, as Moore (2001: 150) states, in the case of heavy metal there is "a strong preference for [equal] tempered pitch" (example 4.13).

3̂ ————— 1̂

7 6 5 4 8

A-aeo: IV⁵ V⁽⁵⁾⁶ VI⁵ VII⁵ I⁵

Example 4.13. “The Sentinel.”

Furthermore, the interplay of different traditions is evident in the introduction of Uriah Heep’s “July Morning” (example 4.14).

8^{va}

Electric Guitar

Organ

F C F

4 (8)

E. Gtr.

Org.

C F C

7 (8)

E. Gtr.

Org.

F C

Example 4.14. Introduction to Uriah Heep’s “July Morning.”

The Hammond organ has established the key of C-major some eight bars before with the triads of IV and I. At the beginning of this excerpt, the guitar employs a C-minor pentatonic scale for the first five bars of the solo, only joining the organ in the occurrence of a major third of the C-major key in mm. 6. From mm. 7 on, the guitar part can be interpreted as being in the fifth mode of the major pentatonic – the so-called natural pentatonic mode (see, e.g. Burbat 1988: 114).

The beginning of the verse of the same song introduces a move from a major versus pentatonic environment to a modal one (example 4.15). The organs chords start, by applying the volume pedal, in such a low volume that they slide to a new mode of C-Aeolian (i.e. parallel minor) so easily that the listener hardly notices the change of mode. Now, the chords and the melody are coherently in the same mode, and support each other. Furthermore, the organ uses voice leading familiar to the practises of *basso continuo* – for instance, there are no parallel fifths in the organ part.

Example 4.15 shows the beginning of the verse. The top staff is labeled 'Vocals' and contains four measures of rests. The bottom staff is labeled 'Hammond' and contains four measures of chords. The chords are labeled Cm, Fm, B^b, and Cm. The key signature has two flats (B^b and E^b).

Example 4.15 shows the beginning of the verse. The top staff is labeled 'Vocals' and contains four measures of rests. The bottom staff is labeled 'Hammond' and contains four measures of chords. The chords are labeled Cm, Fm, B^b, and Cm. The key signature has two flats (B^b and E^b).

Example 4.15. The beginning of the verse of “July Morning.”

These kinds of fusions between different traditions are quite frequent in heavy metal. The mixtures include not only scales and modes, but voice leading, too. This is dealt with in the following.

Like the modal or scalar practises, the voice leading practises of heavy metal derive from various sources. One quite typical feature of heavy metal, as with most rock music, is parallel voice leading. This means that all the constituents of a harmonic unit (or, chord) are lead in the same direction – either chromatically or diatonically (see, e.g. Persichetti 1961: 198). Especially important in heavy metal are the parallel fifths – the same interval that is banned in all text books on traditional harmony and counterpoint. An extreme example on this is presented by Black Sabbaths “Iron Man” from *Paranoid* (1970) (example 4.16).

The image shows a musical score for the first two bars of the verse of "Iron Man" by Black Sabbath. It consists of three staves: Vocals (top), Guitar (middle), and Bass (bottom). The key signature is one sharp (F#) and the time signature is 4/4. The Vocals staff shows a melodic line with a slur over the second bar. The Guitar and Bass staves show a rhythmic accompaniment with parallel motion in the chords, illustrating the concept of parallel voice leading.

Example 4.16. “Iron Man,” the first two bars of the verse.

These kinds of parallel fifths and fourths are also common to the medieval *organum* (e.g. Shepherd 1991: 99; Riemann 1961: 76-77). Still, probably the most important reason for the parallel voice leading is that it is easy to produce all the most common dyads, triads and tetrads with the guitar’s *barré* grip, and to move them across the fret board without changing the grip. However, the same type of voice leading can be detected in other instrumental contexts, too (also, see Moore 1995: 191). For instance, also the vocal harmonies to the chorus of Iron Maiden’s “Running Free” are executed in parallel motions (example 4.17).

The image shows a musical score for the vocal harmonies and guitar accompaniment of "Running Free" by Iron Maiden. It consists of two staves: Vocals (top) and Guitar (bottom). The key signature is one sharp (F#) and the time signature is 4/4. The Vocals staff shows a melodic line with a slur and a triplet marking. The Guitar staff shows a rhythmic accompaniment with parallel motion in the chords, illustrating the concept of parallel voice leading.

Example 4.17. “Running Free.” The vocal harmonies are on the upper, and guitars on the lower staff.

In addition to the parallel voice leading there are more classical continuo-derived practises, too, and quite classical counterpoint between different instrument parts – of course, with the more freely used parallel fifths, unlike in the traditional text book counterpoint (see, e.g. Mann 1971: 82, 86). These features – counterpoint, traditional and parallel voice leading – can occur separately or all together in the same song. For example, in Jimi Hendrix’s “Hey Joe” (1983 [1967]) there are all three kinds of motions (example 4.18). The backing vocals form a contrapuntal *obligato* line C-B-A-A-G[#] for the guitar’s parallel major triads. After some recapitulations this line is harmonized in such a way that abides by classical voice leading rules. The harmony line starts from the third of the original melody following its descending motion and always hitting the nearest consonance of the next chord. It seems clear that the backing vocal choir is derived from a different tradition than the guitar chords.

The image shows three staves of musical notation for the song "Hey Joe". The top staff is labeled "Main vocals" and shows a melody in treble clef. The middle staff is labeled "Backing vocals" and shows a line of chords in treble clef, with the notes C, G, D, A, and E written below the staff. The bottom staff is labeled "Guitar" and shows a line of chords in bass clef, with the notes C, G, D, A, and E written below the staff. The notation is organized into three measures, with the backing vocals and guitar chords aligned with the vocal melody.

Example 4.18. “Hey Joe.” Vocal harmonies on the middle, guitar chords on the bottom stave.

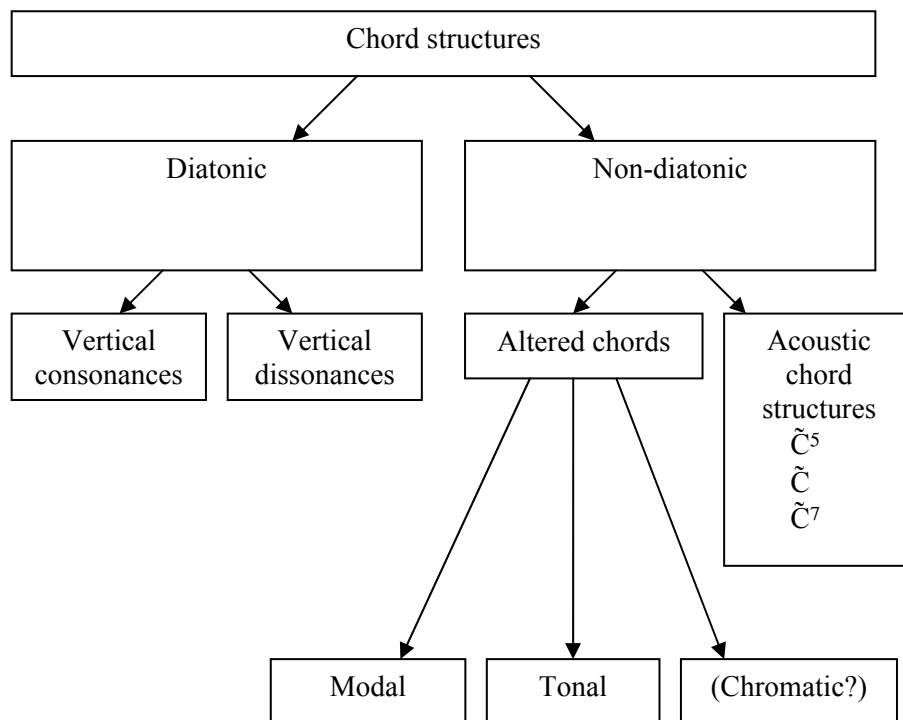
Furthermore, the main vocal line, which is almost the same with the first choir *obligato*, applies a minor third to the last bar giving the song a bluesy pentatonic flavour. Clearly, the song is not pentatonic – the melodies, for instance, are more of the modal type (Aeolian/Dorian/Mixolydian). However, as has been shown, there is interplay of at least three different sources of musical traditions in this song.

In this sense, the instrumental section of “July Morning” is quite different. In fact, it can be analyzed with very traditional tools – even enough so to make a Schenkerian analyst happy (examples 4.19 and 4.20).

5. Chord Structures and Their Relation to Modal/Tonal Context

Context

This chapter deals with typical heavy metal chord structures with the emphasis on their relation to modal and tonal context. Still, other remarks are made when necessary. I have divided heavy metal chords into diatonic and non-diatonic chords, according to their relation to the overall modal scale (example 5.1). Diatonic chords are understood here as chords exclusively employing scale degrees of one single mode, whereas the non-diatonic have at least one scale degree outside of that mode. Non-diatonic chords are subdivided to common altered chords (modal, tonal and chromatic), and chords addressed here as “acoustic.”



Example 5.1. The division of chord structures. “C” represents chord a root on any scale degree. The class of chromatic chords is put in parenthesis and labelled with “?” because their relevance will be questioned below.

As Vincent Persichetti (1961: 238) states, “the altered formation [of the chord] must be foreign to the scale presently in effect.” Here, altered chords are put into three subcategories according to the type of their alteration. The outline for this subdivision is based on Erkki Salmenhaara’s theoretical and analytical writings.¹⁵ The division made by Salmenhaara (1968: 87, 1980: 201-225, 317) is more systematic than, to my knowledge, those made by any other music theorist (e.g. Piston [1962: 276-277], Forte [1962: 96, 355-365], Persichetti [1961: 237-240] or Schönberg [1966: 211-212, 267-271, 421-431]). Salmenhaara’s (1980: 201) *modal altered* chords are those “borrowed” to major or minor environments from the parallel mode (e.g. F-minor chord in C-major is “borrowed” from C-major’s parallel mode C-minor). *Tonal altered* chords effect a temporary shift of tonal centre (e.g. secondary dominants, *ibid*: 212). The rest are called *chromatic altered* chords, and they result from a type of chromatic altering of diatonic chords that cannot be explained by the previous two categories (*ibid*: 317). Here, while the basic concept of categorizing remains the same, some additional and slightly differing criteria are introduced. For instance, the first two categories are extended in such ways that only a few chords fall into the category of chromatic altered chords. Below, I present my chord categorization and make the necessary remarks on features that distinguish Salmenhaara’s division from mine.

5.1. Modal Altered Chords

The first category to fall under the label “altered chords” is the class of modal altered chords. These chords are “borrowed” from some other mode than the present one. In traditional harmony analysis, only possible modes within one tonality are its major and minor forms (e.g. C-major and C-minor). However, by adopting Moore’s modal system the boundaries of this category may be expanded. Hence, in the following analyses the concept of modal altering is also extended to the other modes. In analytic labelling, I have used markings derived from Moore’s system (see e.g. Moore 2001: 54, 1992: 75-76). In this labelling, the abbreviations of mode names are attached to Roman numerals

¹⁵ Professor Erkki Salmenhaara (1941-2002), a composer and musicologist, was one of Finland’s most influential and respected music theorists (see e.g. his obituary in *The Guardian Unlimited* by Guy Rickards, 2002). His treatises *Sointuanalyysi* (Engl. *Harmony Analysis*, 1968) and *Soinnutus* (*Harmonization*, 1980 [1969]) arose mainly from Walter Piston’s *Harmony* (1962) whose theories he furthermore developed. *Sointuanalyysi* is still in use as a text book on harmony in most Finnish conservatoires and universities’ music departments.

where necessary (e.g., dorIV would denote a triad on the fourth degree of Dorian mode). Markings quite similar to this have been used before (see, e.g. Schenker 1954: 111) – yet, not to the same extent.

In the material studied here, the Aeolian appears to be the most common mode. In most cases, modal altering is really a departure from Aeolian. Quite often an Aeolian chord progression is extended with a chord from Dorian mode. This is the case for instance in Judas Priest’s “When the Night Comes Down,”¹⁶ in which the open sixth chord on VI is interpreted as a Dorian loan (example 5.2). That is, an E-Dorian chord in an otherwise E-Aeolian context. The vocal melody, fundamentally kept in $\hat{2}$, locally forms sharp dissonances with chord tones (in the analysis, the major sevenths are especially indicated by $\Delta 7$; octave unisons between chord tones and melody are marked if they have any special significance – in the sixth bar, the resolution of the major seventh to octave can be easily shown this way – otherwise they are left out).

E-aeo: V^5 — 6 VI^5 dor $VI^{(5)6}$ VII^5 I^5 V^5 — 6 VI^5 III^5 V^5 of $\rightarrow V^5$

Example 5.2. “When the Night Comes Down,” a reduction of the transition-like section just before the guitar solo.

In example 5.2 the chords that form passages from V^5 to I^5 (mm. 1-3) and from V^5 back to V^5 (mm. 4-7) are mainly connected in such a way that only one of the two chord tones is moved at a time. The progression from Aeolian VI^5 to Dorian $VI^{(5)6}$, and the cadence-like III^5 - V^5 of V are only exceptions to this rule. Dissonances are arranged to occur mainly in off-beats as passing (mm. 1-2 and 4) or neighbour notes (mm. 5). There are only two down-beat dissonances – the major ninth in I^5 in mm. 3 that gets its resolution to a chord tone only after the second repetition of the passage (not shown

¹⁶ From the album *Defenders of the Faith*, CBS 1984.

here), and the major seventh in mm. 6, which is resolved by the progression III-VofV that consequently changes it to a consonant chord tone.

The interchange between Dorian and Aeolian can also be detected in Cream’s “White Room” (example 5.3). In this case, however, the melodic line strongly underlines D-Dorian. Hence, it is the Aeolian VI that is interpreted as a modal altered chord, or, a modal loan.

D-dor: I VII IV aeoVI VII I

Example 5.3. “White Room,” verse.

A Dorian $\hat{6}$ occurs in “Smoke on the Water,” too (example 5.4). Here the underlining melodic line in the main vocal part – the descending chromatic line from Dorian $\hat{6}$ (dor $\hat{6}$) to Aeolian $\hat{6}$ (aeo $\hat{6}$) – is accompanied with Dorian IV (dorIV) and Phrygian II (phrII). The guitar applies only three-note power chords but still the overall harmony is perceived as major triads due to the vocal part.

G-aeo: dorIV phrII I

Example 5.4. The chords and the melodic line of the chorus section from “Smoke on the Water.”

In terms of traditional harmony analysis, these harmonies are not particularly exceptional – the IV degree from melodic minor and the Neapolitan chord (i.e. major

However, the Locrian interpretation is quite valid for e.g. Black Sabbath’s “Symptom of the Universe” (1975) (examples 5.6 and 5.7) and for a great deal of more contemporary heavy metal influenced by Black Sabbath. For example, listen to any song from Metallica’s *And Justice for all...* (1988) or Mercyful Fate’s *Dead Again* (1998) for these bands the use of the Locrian is quite normative.

A-phr: $\hat{1}$ $\hat{2}$ $\hat{7}$ $\hat{1}$ $\hat{2}$

E-loc: I V I V

Example 5.6. Verse to Black Sabbath: “Symptom of the Universe.” Vocal melody is on the upper staff, chords of the guitar riff on the lower. This section is repeated four times.

A-phr: $\hat{1}$

A-phr: IV II I

D-aeo: I VI V

Example 5.7. The chords following the previous example; repeated twice, then back to the previous example 5.6.

“Symptom of the Universe” offers quite an interesting example – the harmonic background established by the guitar riff starting some bars earlier is clearly in E-Locrian, but the vocal melody seems to be in A-Phrygian. The next section (example 5.7) seems to decide in favour of A-Phrygian with a cadence similar to that used in “Smoke on the Water” (example 5.4 above). Some may even hear this in D-Aeolian due to the semitone relationship heard so often between the chords VI and V in minor modes. Still, the melody seems to be persistently in the mode of A-Phrygian – at least I hear it that way. In my opinion, “Symptom” creates a sort of a polymodal effect. For

some this might be proof that this type of analytical method cannot be relevant to this kind of music. However, I suggest that this type of analysis can offer some invaluable insights into the organising of musical structures that may, at face value, seem very simple but are often far more complex.

5.2. Tonal Altered Chords

The effect of the *tonal altered* chords is directed towards the tonal centre. In these cases the tonal function of a chord is altered. Usually in the process, some non-tonic chord degree is given the status of a temporary tonal centre (see, e.g. Salmenhaara 1968: 95). This is also near to Schenker's (1954: 256) *tonicalization*. From the point of view of traditional harmony analysis, the most typical tonal altered chords are the secondary dominants – like those in Uriah Heep's "July Morning" (1971) (example 5.8). When the C-minor triad is changed to a C-major its tonal function is changed, too – from the tonic of C-Aeolian to the dominant of F.

The musical score for 'July Morning' shows a progression of four measures. The top staff (Vocals) has notes G4, A4, B4, C5. The Organ part has chords Cm, C, F5, G5. The Guitar part has chords C5, C5, F5, G5. The figured bass symbols above the notes are 3̂, b3̂, 4̂, 5̂. Below the guitar staff, Roman numerals are given: C-aeo: I, Vof, IV, V. An arrow points from Vof to IV.

Example. 5.8. A secondary dominant in "July Morning."

As often happens in Uriah Heep's music, the Hammond organ fills in the guitar's power chords into triads. Again it is noteworthy that the organist applies quite classical voice leading whereas the guitar is played in parallel motions. Also the melodic line of the vocals is treated in a manner that is common to classical harmony with secondary dominants. This is again an example of the interplay between two traditions – guitar-derived modality and classical contrapuntal voice leading.

However, in heavy metal the secondary subdominants seem to be more common. For instance, the chords of “Hey Joe” follow the cycle of fifths, but in a reversed order, and form the chain of secondary subdominants: IV of IV of IV of IV of I. Similar chains can be found, for example, in Deep Purple’s “Hush” (1988 [1968]), “Fireball” (1971), and “Burn” (1974), Rainbow’s “Kill the King” (1978), and “Long Live Rock ‘n’ Roll” (1978), Judas Priest’s “Devil’s Child” (1982), and Black Sabbath’s “A National Acrobat” (1973). Furthermore, all of these are in Aeolian mode.

5.3. Acoustic Chords and Chromatic Altered Chords

A special interest of this study is in the non-diatonic chords that do not change the mode or a tonal centre, but sort of fuse into a single tone to support the chord’s fundamental tone. To the best of my knowledge, these chords have not been subjected to any analytic study. Although Moore (1992: 81) briefly touches on the subject: “rock/pop/soul tends to conceive its harmonies as indivisible units rarely subject to voice leading principles.” Yet, no further explanation of these “indivisible units” is given. As far as I know, this is the first effort to systematically take this matter under discussion (for comparison, see Lilja 2001). The structures that I call *Acoustic chords* and the chromatic altered chords are put under the same title here because, as will be shown, these categories are at least overlapping, and sometimes overriding each other.

As discussed in Chapter 2, this category is made of chords that follow the harmonic series. Due to the distortion and high volumes produced by electric guitar the chords, which abide by the lowest partials of the harmonic series, produce much a clearer sound than other chord structures. Depending on the level of distortion, these structures are the power chord, the major triad, and the dominant seventh structures. Actually, these Acoustic chords are not really altered in the sense discussed above, although in their tonal or modal surroundings they may appear to be strange deviations.

For example, the major triad on the first degree in “White Room” (example 5.3 above) is not a secondary dominant – it does not need to resolve, e.g. to the IV degree – but is unambiguously tonic-functioned. Nor it is a modal altered chord – this kind of interpretation would presume that the modal environment changes from fundamentally

minor (Dorian) to major (Mixolydian). The major third of the chord is not perceived as modally significant, but as a vertically important part of the chord's sound. For instance, one can discover the significance of this by playing a D-minor triad instead of this D-major (as sometimes is done in error).

“The Mule” (1971) of Deep Purple has quite similar effect (example 5.9). The excerpt is analyzed in A-Mixolydian because the instrumental section before the sung verse quite clearly establishes the mode with the chords I-VII-I and the melodic tones A-B-C#-D-E-F#-G. Analyzing the II degree chord as a Lydian modal altered chord in this context does not quite capture the nature of the chord since the chord's major third is “melted” into the chord structure without establishing a new scale. It would be even harder to interpret it as a secondary dominant, since there is no chord of V. Then the II is more tied to the next chord of IV. Actually, a similar chord progression can be found in “July Morning” (with V, though), but even more so in The Beatles’ “Sgt. Pepper’s Lonely Hearts Club Band” (1967).

A-mix: I II IV I

I —————

Example 5.9. The verse of “The Mule.”

As in “July Morning” these chords in “The Mule” are played on the Hammond organ. However, the acoustic features mentioned in regard to the electric guitar are quite applicable to the Hammond organ, too. Furthermore, this can be taken as an example of how the guitar-derived solutions can be switched to another instrumental context.

The next example will further illuminate on the difference between a modal altered and an Acoustic chord. This excerpt is from the “outro” riff to Dio’s “Shame on the Night” (example 5.10). Apparently, the passing chord II⁵ between the I and the III degree includes an A-Dorian altered tone (F#). However, the F#, while forming a perfect fifth

Chromatic Altered Chords?

Next I will present the issues concerning the supposed class of chromatic altered chords. Tonal and modal altered chords are moved from another tonality or mode to some other environment. Chromatic altered chords are made by altering the chords of a key (Salmenhaara 1980: 317). If compared to those of Salmenhaara, the previous two categories are extended in such a way that it diminishes the number of chromatic altered chords. For instance, the category of modal altered chords is much wider than Salmenhaara's (1968: 88-89) due to the modal system. However, depending on the point of view some chords could be placed to this category. For instance, a diminished chord that sometimes occurs in Aeolian context could be analyzed as a chromatically altered formation. This is done, for example, in Dio's "Holy Diver" (1983) (example 5.11).

C-aeo: VI⁵ VII⁵ hmVII⁵ I⁵

Example 5.11. The dyad of the diminished fifth in "Holy Diver."

Although the diminished fifth is here presented as an alien formation to Aeolian mode, it can be interpreted as a modal altered chord. Of course, this requires that the Harmonic minor (abbr. hm) is accepted as a modal scale. If we recognise the influence of classical music in heavy metal, this seems reasonable enough. Furthermore, in Western music as a whole the harmonic minor is one of the most common scales. However, in the larger scale analysis these kinds of intervallic structures are usually interpreted as chromatic passing chords. Still, as a single unit it is not a chromatic but a modal chord, because it can be found in several modes. Even though, now the relation between the Aeolian mode and the Harmonic minor mode is much more accurate – since the Aeolian is much more common in heavy metal, the harmonies abiding by Harmonic minor should be (in most cases) interpreted as altered formations.

In the following, there are further examples of seemingly chromatic chords with their likely interpretations. One of these is the harmonic formation between the chord and

The $E^{7\sharp 9}$ can be interpreted as a chromatic altered chord $I^{7\sharp 9}$, but still, there is another perspective to this. The four lowest tones of the chord form an acoustic dominant seventh structure \tilde{I}^7 that supports the fundamental E. In terms of harmony analysis this means that, in a sense, there is only a single tone (E) that is supported by the structure abiding by its harmonic series. Furthermore, according to this interpretation the chord's minor third G is a part of the minor pentatonic scale of the melody – the guitarist supports the melody with his instrument.

5.4. Diatonic Vertical Dissonances

Since the diatonic vertical consonances are self-explanatory (i.e. they follow both the mode and the acoustic structure), this chapter will deal with diatonic *vertical dissonances*. These chords follow the prevailing mode, but are acoustically difficult in a way that was discussed in Chapter 2 – with the distortion and high volumes their construction cause dissonant effects. For instance, all the chords of the chorus of “July Morning” are diatonic (example 5.14).

The image shows two staves of music: Hammond (top) and Kitara (bottom). The key signature has two flats (Bb and Eb). The Hammond part consists of five chords: Eb, Gm?, Ab, Bb, and Cm?. The Kitara part consists of five chords: Eb5, G5, Ab5, Bb5, and C5. Vertical lines connect the notes of the Hammond chords to the notes of the Kitara chords. A dashed box encloses the final two chords (Bb and Cm? in Hammond; Bb5 and C5 in Kitara).

Example 5.14. The chorus section of “July Morning.”

The organist fills in the guitar's power chords into diatonic triads. However, if the chords are explored aurally, it can be noticed that the Gm triad is considerably more unstable than the other chords. I suggest that the imbalance of this chord is due to its minor formation. The minor third does not support the harmonics of G, but causes different harmonic series instead, and thus considerable beating, too. This is further

emphasized due to the guitar's power chords that strongly support the harmonics of G. The reason why the Cm triad on the last bar does not cause the same kind of effect is probably that the chord is rhythmically interrupted before the rise of a different harmonic series. This excerpt can be conveniently listened to by using the panorama potentiometer to listen to one channel at a time – first the right channel with Hammond only, then both channels to get the guitar chords, too. As mentioned above, it seems that the similar kinds of effects as those of the guitar are raised by the Hammond organ. Of course, when listening to these phenomena one has to keep in mind that only a high enough volume will do justice to the harmonics.

According to the chord categorisation presented here, all loud and distorted harmonic structures that do not abide by the harmonic series of the root tone are vertical dissonances. Thus, the open-minor-sixth dyad belongs to this category, too. By listening to the aforementioned examples (e.g. “The Sentinel”) it is possible to detect the dissonance of the sixth when compared to e.g. the power chord of the fifth. More examples on the open-minor-sixth can be heard in e.g. the following songs: AC/DC: “Highway to Hell” (1979); Dio: “Holy Diver” (1983), “Gypsy” (1983), and “One Night in the City” (1984); Iron Maiden: “The Number of the Beast” (1982).

The phenomenon of vertical dissonance is very clear in a contemporary example – Mercyful Fate's “Banshee” (1998) (example 5.15).

Musical score for "Banshee" showing Vocals, Guitar R, Guitar L, and Bass staves. The score is divided into three sections: a), b), and c). Section a) shows a II degree chord in its first inversion. Section b) shows a III degree chord. Section c) shows a V3-4 chord. The score includes a tempo marking of quarter note = 72 and a circled 4 with "(echo)" above it. A bracket on the left groups the guitar and bass staves under the label "E-aeo:".

E-aeo:	Gtr.R +Bass:	I	II	III	I	VII
	Gtr.L:	I	VII	VI	I	VII
						V3-4

Example 5.15. An excerpt of the chorus section of "Banshee."

When listening to this example, there appear to be some strange dissonances in the places marked with a) and b). However, when notated, they appear to be quite consonant in a traditional sense. If the left and right channels are listened to separately this controversy could be explained as follows: The bass and the vocals are sounding in both channels. In the right channel, there is only one guitar sounding (marked as "Guitar R" in the example) that is playing in unison with the bass. The right-channel guitar and the bass with vocals refer to E-Aeolian chord degrees I, II, and III. On the other hand, the guitar on the left channel (Guitar L) plays power chords on the I, VII, and VI degree. In a) this results a II degree chord in its first inversion, i.e. the intervals of a minor third and a minor sixth. According to the acoustic features of loud and distorted chords discussed in Chapter 2, both of these are categorized as vertical dissonances by definition due to their intervallic structure. This can be easily compared to a similar chord in mm. 2, where all the instruments support the VII (D). It is significant that the bass supports the harmonics of D – due to this, the D-chord of mm. 2 does not beat in the way that the "D-chord" does in mm. 1.

The situation in b) is slightly different. Here all except the left-channel guitar form a III degree chord. The left-channel guitar's VI creates two dissonances – not only a major

seventh with the vocals but also a low fourth with the bass. This fourth (G-C) creates a harmonic series of C, but it is suppressed by the series of G that is emphasized by all the other instruments, and thus, left with little weight – still, enough to create a fuzzy sound. “Banshee” includes yet another interesting phenomenon. In c) the vocal line clearly reaches the tonic E, yet the guitars and the bass are in the V degree. This creates a sort of reversed suspended-fourth effect (V^{3-4}). Actually, in this case we can hear two separate tonal functions (the tonic and the dominant) without them sounding at all controversial or dissonant.

The perspectives presented here give some explanation of the frequent avoidance of vertical dissonances in heavy metal music. There are several ways of doing this – one being the use of Acoustic chords in spite of tonal or modal context. However, if the dissonant structures are used, they can be e.g. arpeggiated to reduce the vertical beating – then the beating frequencies are not played together. This is done in, for example Judas Priest’s “When the Night Comes Down” where a minor triad is played with arpeggios, although with heavy distortion. Furthermore, it seems likely that the increasing amount of distortion has resulted in a dropping of the thirds altogether – when the distortion grows, the beating resulting from the harmonics of the equal-tempered major third will rise accordingly. The tendency to use only or mainly dyads has been clear in the run up to the 1980’s and up to the present day. Of course, often these dissonances are applied for musical purposes – the alternation between consonance and dissonance is really a basic element of any melodic or harmonic construction. Nevertheless, there is often a decision to be made (consciously or unconsciously) whether to use a vertical or a modal/tonal dissonance.

6. Conclusions

What has been done here is a musicological survey of heavy metal chord structures from various points of view. The study has covered their acoustic constructions, their relation to traditional music analysis, and their most influential musical sources in history. Furthermore, the chord categorizing principles were used as an instrument of music theory to discuss the chords' relations to their environments. In the light of this study, heavy metal music has proved to be far more complicated than has been previously suggested (cf. Everett 2000: 330-335).

The acoustic characteristics of heavy metal chords have not been studied before to this extent – for instance, Walser (1993: 43) devoted only a single paragraph to the acoustics. Yet, these acoustic features bring a distinctive sound to the music, and have a great deal of influence on the perception of apparently (when notated) simple formations. Furthermore, it seems that the perspectives presented here can explain the frequent avoidance of the vertically dissonant structures in heavily distorted metal music. Neither can we ignore the fact that heavy metal music derives from various musical traditions. The classical major/minor tonal influences are often paralleled with pentatonic blues-derived contents, as indeed they are with the modal scales. Thus, the music in question is an explicitly multi-traditional one. It is quite interesting (and perhaps surprising) that heavy metal harmony often tends to use solutions that were established in the modal music of the Renaissance and furthermore fixed during the Baroque era. In heavy metal, this kind of chord connecting is coupled with pentatonic and blues-derived features (although, mostly within the equal-tempered system).

However, this study leaves many questions unanswered. For instance, the acoustics of heavy metal chords has to be subjected to further, empirical studies. In fact, the acoustic measuring of the chords will be one of my next objects of study, in addition to the way in which musicians and the listeners perceive the chord roots and fundamental tones. These studies should involve at least spectral analysis and the methods applied for the studies of musical cognition. Also, the functional tonal hierarchies of heavy metal chord progressions have to be further explored (although this has been done extensively in Lilja 2002).

Furthermore, the analyses made here have emphasized the vertical aspects at the expense of the horizontal, although some features were explored with regard to voice leading (e.g. voice leading analysis of “July Morning”). The horizontal aspects will be covered more thoroughly in the next phase of my study on heavy metal harmony. In fact, the analyses made here are the first step to a multi-level analytic model that should be capable of dealing with the music in several hierarchical levels – from the details to the overall “fundamental” structures. To accomplish this I will take two major theories as starting points – the Schenkerian and Riemannian – and explore their possibilities while using heavy metal as an analytic corpus. I strongly believe in the need for a detailed analysis of heavy metal music. Armed with a deeper understanding of the nuances of the music itself, it will be easier to embark on larger scale analyses of all aspects of heavy metal music; from the musical to the social and cultural perspectives and onwards.

References

- AMG All Music Guide. <http://www.allmusic.com/>.
- Backlund, Kaj 1983. *Improvisointi pop/jazzmusiikissa [Improvisation in pop/jazz music]*. In Finnish. Helsinki: Musiikki Fazer.
- Benade, Arthur H. 1976. *Fundamentals of Musical Acoustics*. New York: Oxford University Press.
- Berger, Harris. M. 1999. *Metal, Rock, and Jazz – Perception and the phenomenology of musical experience*. Hanover & London: University Press of New England.
- Burbat, Wolf 1988. *Die Harmonik des Jazz*. Kassel: Bärenreiter-Verlag Karl Vötterle GmbH & Co.
- Burks, John 1984. "A Rare Interview." In Obrecht (ed.) 1984 *The Masters of Heavy Metal*. New York: GPI Publications. Pp. 18-22.
- Cook, Perry K. (ed.) 1999. *Music, Cognition and Computerized Sound – And Introduction to Psychoacoustics*. Cambridge: The MIT Press.
- Covach, John 1997. "We Won't Get Fooled Again: Rock Music and Musical Analysis." In *Theory Only* 13:1-4, pp. 119-141.
- Covach, John & Boone, Graeme M. (eds.) 1997. *Understanding Rock – Essays in Musical Analysis*. New York: Oxford University Press.
- "Death Metal/Black Metal" 2004. On AMG All Music Guide (accessed May 16, 2004), <http://www.allmusic.com/cg/amg.dll?p=amg&uid=UIDSUB040405161302241951&sq|=C384>.
- Drabkin, William 2003. "Fourth." *Grove Music Online* ed. L. Macy (Accessed 15 November, 2003), <http://www.grovemusic.com>.
- Everett, Walter (ed.) 2000a. *Expression in Pop-Rock Music – A Collection of Critical and Analytical Essays*. New York & London: Garland Publishing, Inc.
- Everett, Walter 2001. *The Beatles as Musicians – The Quarry Men through Rubber Soul*. New York: Oxford University Press.
- Forte, Allen 1962: *Tonal Harmony in Concept and Practice*. New York: Holt, Rinehart and Winston.
- Forte, Dan 1977. "Dave Davies of 'The Kinks'." *Guitar Player* 11/9, pp. 24, 48-53.
- Frith, Simon 1983. *Sound Effects – Youth, leisure, and the politics of rock*. London: Constable.
- "Fundamental bass" 2004. *Grove Music Online* ed. L. Macy (Accessed 16 May, 2004), <http://www.grovemusic.com>.
- Greated, Clive 2003a. "Beats." *Grove Music Online* ed. L. Macy (Accessed 15 November, 2003), <http://www.grovemusic.com>.

- Greated, Clive 2003b. "Combination tone." *Grove Music Online* ed. L. Macy (Accessed 15 November, 2003), <http://www.grovemusic.com>.
- Harrison, Daniel 1994. *Harmonic Function in Chromatic Music – A Renewed Dualist Theory and an Account of Its Precedents*. Chicago & London: The University of Chicago Press.
- "Heavy Metal" 2004. *AMG All Music Guide* (accessed May 7, 2004).
<http://www.allmusic.com/cg/amg.dll?p=amg&uid=UIDSUB020404230642210328&sq=C655>.
- "How to read microphone specifications" 2004. *DPA Microphones* (accessed 23 May 2004).
<http://www.dpamicrophones.com/>.
- Iron Maiden Guitar Tab Edition* 1994. Miami: Warner Bros Publications U.S. Inc.
- Jeppesen, Knud 1975. *Kontrapunkti*. Translated in Finnish by Osmo Lindeman. Helsinki: Musiikki Fazer.
- Lassfolk, Kai 1996. "Simulation of Electron Tube Audio Circuits." Conference paper. ICMC 1996.
- Lilja, Esa 2001. "Harmonic Function in Modal Heavy Metal". *Conference Proceedings of the 11th conference of IASPM*, pp. 452-462. Ed. by Kimi Kärki, Rebecca Leyndon & Henri Terho. IASPM-Norden.
- Lilja, Esa 2002. *Funktionaalinen harmonia modaalisessa heavyrockissa – modaalis-funktionaalinen analyysimalli [Functional harmony in modal heavy rock – A modal-functional analytic model]*. Master's thesis in Finnish. University of Helsinki.
- Lilja, Esa 2004. "Heavymetalin sointurakenteiden erityispiirteet." *Etnomusikologian vuosikirja* (in print).
- Lindley, Mark/Campbell, Murray & Greated, Clive 2003. "Interval." *Grove Music Online* ed. L. Macy (Accessed 15 December, 2004), <http://www.grovemusic.com>.
- Lindley, Mark 2004. "Just [pure] intonation – 1. General theory." *Grove Music Online* ed. L. Macy (Accessed 21 May, 2004), <http://www.grovemusic.com>.
- Lloyd, Llewelyn S. & Rastall, Richard 2004. "Pitch nomenclature." *Grove Music Online* ed. L. Macy (Accessed 21 May, 2004), <http://www.grovemusic.com>.
- Mann, Alfred (ed.) 1971. *The Study of Counterpoint from Johann Joseph Fux's Gradus ad Parnassum [1725]*. Revised edition. New York & London: W. W. Norton & Company.
- Marshall, Wolf 1997. "Riffer Madness." In *Guitar World Presents Metallica*, pp. 124-27. Edited by Jeff Kitts, Brad Tolinski & Harold Steinblatt. New York: Music Content Developers, Inc.
- Martin, Henry 1996. *Charlie Parker and Thematic Improvisation*. Studies in Jazz, No. 24. Institute of Jazz Studies, Rutgers – The State University of New Jersey. Lanham, Md., [sic] & London: The Scarecrow Press, Inc.

- Mathews, Max 1999. "The Ear and How It Works." In Cook, Perry K. (ed.) *Music, Cognition and Computerized Sound – And Introduction to Psychoacoustics*. Cambridge: The MIT Press. Pp. 1-10.
- McEvoy, Chris 2000. "Be The Who – Long live rock's elder statesmen." *The Complete The Who Concert Guide*, (accessed 20 May, 2004)
<http://www.thewholive.de/2000/zeitung/2000-07-01.html>.
- Merwe, Peter van der 1989. *Origins of the Popular Style*. Oxford: Clarendon Press.
- Meyer, Leonard B. 1956. *Emotion and Meaning in Music*. Chicago: The University of Chicago Press.
- Mickelsen, William C. 1977 *Hugo Riemann's Theory of Harmony and History of Music, Book III*. Lincoln and London: University of Nebraska Press.
- "Mode" 2003. *Grove Music Online* ed. L. Macy (Accessed 15 December, 2003),
<http://www.grovemusic.com>.
- Moore, Allan 1992. "Patterns of harmony." *Popular Music* 11/1, pp. 73-106.
- Moore, Allan 1995. "The so-called 'flattened seventh' in rock." *Popular Music* 14/2, pp. 185-201.
- Moore, Allan F. 2001. *Rock: The primary text – Developing a musicology of rock*. Second edition. Aldershot: Ashgate.
- Moore, Allan F. (ed.) 2003. *Analyzing Popular Music*. Cambridge: Cambridge University Press.
- Moore, Allan F. 2004. "Hard rock." *Grove Music Online* ed. L. Macy (Accessed 26 April, 2004), <http://www.grovemusic.com>.
- Moore, Brian C.J. 2003. "Consonance, §2: Psychoacoustic factors." *Grove Music Online* ed. L. Macy (Accessed 15 May, 2003), <http://www.grovemusic.com>.
- Motte, Diether de la 1987. *Harmoniaoppi [Harmonielehre]*. Translated in Finnish by Mikko Heiniö. Helsinki: Suomen Musiikkitieteellinen Seura.
- Murray, Charles Shaar 2003. "Power chord pioneer's artful life" *The Observer*, (accessed 20 May, 2004) http://observer.guardian.co.uk/uk_news/story/0,6903,873307,00.html.
- Obrecht, Jas (ed.) 1984. *The Masters of Heavy Metal*. New York: GPI Publications.
- Padilla, Alfonso 1997. "Dialektinen lähestymistapa musiikkitieteessä II [A dialectic approach in musicology, part II]." In Finnish. *Musiikki* 2, pp. 135-194.
- Pennanen, Risto Pekka 1999. *Westernisation and Modernisation in Greek Popular Music*. Academic Dissertation. Acta Universitatis Tamperensis 692. University of Tampere, Finland.
- Persichetti, Vincent 1961. *Twentieth Century Harmony – Creative Aspects and Practice*. London: Faber and Faber Limited.

- Pierce, John 1999a. "Introduction to Pitch Perception." In Cook, Perry K. (ed.) *Music, Cognition and Computerized Sound – And Introduction to Psychoacoustics*. Cambridge: The MIT Press. Pp. 57-70.
- Pierce, John 1999b. "Passive Nonlinearities in Acoustics." In Cook, Perry K. (ed.) *Music, Cognition and Computerized Sound – And Introduction to Psychoacoustics*. Cambridge: The MIT Press. Pp. 277-284.
- Piston, Walter 1962. *Harmony*. Third edition. New York: W. W. Norton & Co, Inc.
- Porter, James 2004. Mode, §IV: Modal scales and traditional music – 1. Modal scales as a new musical resource." *Grove Music Online* ed. L. Macy (Accessed 2 June, 2004), <http://www.grovemusic.com>.
- Powers, Harold S. & Cowdery, James 2004. "Mode, §IV, 2: Modal scales and melody types in Anglo-American folksong." *Grove Music Online* ed. L. Macy (Accessed 2 June, 2004), <http://www.grovemusic.com>.
- Powers, Harold S. & Widdess, Richard 2004. Mode, §V, Middle East and Asia." *Grove Music Online* ed. L. Macy (Accessed 2 June, 2004), <http://www.grovemusic.com>.
- Powers, Harold S. & Wiering Frans 2004a. "Mode, §I, The term." *Grove Music Online* ed. L. Macy (Accessed 2 June, 2004), <http://www.grovemusic.com>.
- Powers, Harold S. & Wiering Frans 2004b. "Mode, §III, Modal theories and polyphonic music: Systems of 12 modes." *Grove Music Online* ed. L. Macy (Accessed 5 June, 2004), <http://www.grovemusic.com>.
- Rameau, Jean-Philippe 1971. *Treatise on Harmony [Traité de l'harmonie, 1722]*. Translated with an introduction by Philip Gosset. New York: Dover Publications, Inc.
- Resnicoff, Matt 1989. "Flailing your way to god – The Pete Townshend interview, Part II." *Guitar Player* 23/10, pp. 66-82, 131.
- Rickards, Guy 2002. "Erkki Salmenhaara - Finnish music from the avant-garde to the euphonious." *The Guardian Unlimited*. May 23, 2002 (accessed January 15, 2004). <http://www.guardian.co.uk/obituaries/story/0,3604,720443,00.html>
- Riemann, Hugo 1961. *Geschichte der Musiktheorie im IX.-XIX. Jahrhundert*. Dritte auflage. Hildesheim: Georg Olms Verlagsbuchhandlung.
- Riemann, Hugo 1977. "History of Music Theory, Book III." Transl. and ed. by William C. Mickelsen. In Mickelsen 1977 *Hugo Riemann's Theory of Harmony and History of Music, Book III*, pp. 105-251. Lincoln and London: University of Nebraska Press.
- Rosen, Steve 1977a. "Jimmy Page." *Guitar Player* 11/7, pp. 32-58.
- Rosen, Steve 1977b. "John Paul Jones – Zeppelin's Great Bassist." *Guitar Player* 11/7, pp. 30, 96-104.
- Rosen, Steve 1984. "Blackmore's Rainbow." In Obrecht (ed.) 1984 *The Masters of Heavy Metal*. New York: GPI Publications. Pp. 58-67.

- Rossing, Thomas D. 1990. *The Science of Sound*. Reading, Massachusetts: Addison-Wesley Publishing Company.
- Russ, Brian 2004. *The BNR Metal Pages*. (accessed 7 May, 2004) <http://www.bnrmetal.com/>.
- Sadai, Yizhak 1980. *Harmony in its systemic and phenomenological aspects*. Translated in English by J. Davis & M. Shlesinger. Jerusalem: Yanetz Ltd.
- Salmenhaara, Erkki 1968. *Sointuanalyysi [Harmony analysis]*. Helsinki: Otava.
- Salmenhaara, Erkki 1980 [1969]. *Soinnutus [Harmonization]*. Second edition. Helsinki: Otava.
- Scharfglass, Matt 2004. "Steppenwolf 'Born to Be Wild.'" *Guitar World* 25/5, p. 111.
- Schenker, Heinrich 1954 [1906]. *Harmony*. Edited and annotated by Oswald Jonas, translated by Elisabeth Mann Borgese. Chicago & London: University of Chicago Press.
- Schenker, Heinrich 1979. *Free Composition (Der freie Satz) – Volume III of New Musical Theories and Fantasies*. Transl. and ed. by Ernst Oster. New York & London: Longman.
- Schoenberg, Arnold 1967. *Fundamentals of musical composition*. Edited by G. Strang & L. Stein. London & Boston: Faber & Faber.
- Schönberg, Arnold 1966 [1922]: *Harmonielehre*. 7. Auflage. (S.l.) Universal Edition.
- Seeger, Charles 1977. *Studies in Musicology 1935 - 1975*. Berkeley, Los Angeles & London: University of California Press.
- Shepherd, John 1991. *Music as Social Text*. Cambridge: Polity Press.
- Stuessy, Joe 1994. *Rock and Roll – Its History and Stylistic Development*. New Jersey: Prentice-Hall Inc.
- Titon, Jeff Todd 1977. *Early Downhome Blues – A Musical and Cultural Analysis*. Urbana: University of Illinois Press.
- Tolonen, Jouko 1969. *Mollisoinnun ongelma ja unitaarinen intervalli- ja sointutulkinta*. Acta Musicologica Fennica III. Helsinki: Suomen musiikkiteeelin seura.
- Varney, Mike 1984. "Judas Priest." In Obrecht (ed.) 1984 *The Masters of Heavy Metal*. New York: GPI Publications. Pp. 124-141.
- Wagner, Naphtali 2003. "Domestication of Blue Notes in the Beatles' Songs." *Music Theory Spectrum* 25/2, pp. 353-365.
- Walser, Robert 1992. "Eruptions: heavy metal appropriations of classical virtuosity." *Popular Music* 11/3, pp. 263-308.
- Walser, Robert 1993. *Running with the Devil – Power, Gender and Madness in Heavy Metal Music*. Hanover: University Press of New England.
- Walser, Robert 2004a. "Heavy metal." *Grove Music Online* ed. L. Macy (Accessed 26 April, 2004), <http://www.grovemusic.com>
- Walser, Robert 2004b. "Pop, §III: North America – 3. The 1960s." *Grove Music Online* ed. L. Macy (Accessed 26 April, 2004), <http://www.grovemusic.com>

- Webb, Martin K. 1984. "Ritchie Blackmore with Deep Purple." In Obrecht (ed.) 1984 *The Masters of Heavy Metal*. New York: GPI Publications. Pp. 54-57.
- Webster, James 2004."Bass (i)." *Grove Music Online* ed. L. Macy (Accessed 16 May, 2004), <http://www.grovemusic.com>
- Whitehill, Dave 1989. "A Heavy Metal Primer – The Fundamentals of Hard Rock Technique." *Guitar World* 10/6, pp. 120-134.
- Williams, Peter & Ledbetter, David 2004. "Figured bass." *Grove Music Online* ed. L. Macy (Accessed 16 May, 2004), <http://www.grovemusic.com>
- Zarlino, Gioseffo 1968. *The Art of Counterpoint – Part Three of Le Institutioni harmoniche, 1558*. Translated by Guy A. Marco and Claude V. Palisca. New York: W. W. Norton & Company Inc.

Discography

- Accept 1985. *Metal Heart*. Sony.
- AC/DC 1979. *Highway to Hell*. Atlantic.
- Baez, Joan 1975. *Diamonds & Rust*. A&M Records SP-4527
- Beatles, The 1967. *Sgt. Pepper's Lonely Hearts Club Band*. EMI.
- Black Sabbath 1970. *Black Sabbath*. Vertigo.
- Black Sabbath 1970. *Paranoid*. Vertigo.
- Black Sabbath 1973. *Sabbath Bloody Sabbath*. WMA.
- Black Sabbath 1975. *Sabotage*. Nems.
- Cream 1968. *Wheels of Fire*. Polydor.
- Deep Purple 1970. *Deep Purple in Rock*. Harvest.
- Deep Purple 1971. *Fireball*. EMI.
- Deep Purple 1972. *Machine Head*. EMI.
- Deep Purple 1974. *Burn*. EMI.
- Deep Purple 1988. *Singles – A's & B's*. EMI.
- Dio 1983. *Holy Diver*. Phonogram.
- Dio 1984. *The Last in Line*. Phonogram.
- Dylan, Bob 1967. *John Wesley Harding*. Columbia CD 63601
- Hendrix, Jimi 1967. *Purple Haze*. Single. Polydor.
- Hendrix, Jimi 1983. *The Singles Album*. Compilation. Polydor. 827 369-2
- Iron Maiden 1980. *Iron Maiden*. EMI.
- Iron Maiden 1981. *Killers*. EMI.
- Iron Maiden 1982. *The Number of the Beast*. EMI.

Iron Maiden 1984. *Powerslave*. EMI.
Iron Maiden 1986. *Somewhere in Time*. EMI.
Judas Priest 1977. *Sin After Sin*. CBS.
Judas Priest 1982. *Screaming for Vengeance*. CBS.
Judas Priest 1984. *Defenders of the Faith*. CBS.
Led Zeppelin 1970. *II*. Atlantic.
Mercyful Fate 1998. *Dead Again*. Metal Blade Records.
Metallica 1988. *...And Justice For All*. Vertigo.
Ozzy Osbourne 1981. *Blizzard of Ozz*. CBS.
Ozzy Osbourne 1987. *Randy Rhoads Tribute*. CBS.
Rainbow 1978. *Long live rock 'n' roll*. Polydor.
Steppenwolf 1968. *Steppenwolf*. ABC Dunhill. 50029
Uriah Heep 1971. *Look at Yourself*. Bronze.
Who, The 1970. *Live at Leeds*. Polydor.

Appendix I

Some combination tones of the A-major triad with justly tempered intervals.

While some differences come out negative it is not relevant to this study – as in Arthur Benade’s study (1976: 257) “it is the *magnitude* of the frequency difference that matters to us here.”

f_2-f_1		f_1	$2f_1$	$3f_1$	$4f_1$	$5f_1$	$6f_1$	$7f_1$	$8f_1$
		110	220	330	440	550	660	770	880
f_2	165	55	-55	-165	-275	-385	-495	-605	-715
$2f_2$	330	220	110	0	-110	-220	-330	-440	-550
$3f_2$	495	385	275	165	55	-55	-165	-275	-385
$4f_2$	660	550	440	330	220	110	0	-110	-220
$5f_2$	825	715	605	495	385	275	165	55	-55
$6f_2$	990	880	770	660	550	440	330	220	110
$7f_2$	1155	1045	935	825	715	605	495	385	275
$8f_2$	1320	1210	1100	990	880	770	660	550	440

f_3-f_1		f_1	$2f_1$	$3f_1$	$4f_1$	$5f_1$	$6f_1$	$7f_1$	$8f_1$
		110	220	330	440	550	660	770	880
f_3	220	110	0	-110	-220	-330	-440	-550	-660
$2f_3$	440	330	220	110	0	-110	-220	-330	-440
$3f_3$	660	550	440	330	220	110	0	-110	-220
$4f_3$	880	770	660	550	440	330	220	110	0
$5f_3$	1100	990	880	770	660	550	440	330	220
$6f_3$	1320	1210	1100	990	880	770	660	550	440
$7f_3$	1540	1430	1320	1210	1100	990	880	770	660
$8f_3$	1760	1650	1540	1430	1320	1210	1100	990	880

f_4-f_1		f_1	$2f_1$	$3f_1$	$4f_1$	$5f_1$	$6f_1$	$7f_1$	$8f_1$
		110	220	330	440	550	660	770	880
f_4	275	165	55	-55	-165	-275	-385	-495	-605
$2f_4$	550	440	330	220	110	0	-110	-220	-330
$3f_4$	825	715	605	495	385	275	165	55	-55
$4f_4$	1100	990	880	770	660	550	440	330	220
$5f_4$	1375	1265	1155	1045	935	825	715	605	495
$6f_4$	1650	1540	1430	1320	1210	1100	990	880	770
$7f_4$	1925	1815	1705	1595	1485	1375	1265	1155	1045
$8f_4$	2200	2090	1980	1870	1760	1650	1540	1430	1320

f_3-f_2		f_2	$2f_2$	$3f_2$	$4f_2$	$5f_2$	$6f_2$	$7f_2$	$8f_2$
		165	330	495	660	825	990	1155	1320
f_3	220	55	-110	-275	-440	-605	-770	-935	-1100
$2f_3$	440	275	110	-55	-220	-385	-550	-715	-880
$3f_3$	660	495	330	165	0	-165	-330	-495	-660
$4f_3$	880	715	550	385	220	55	-110	-275	-440
$5f_3$	1100	935	770	605	440	275	110	-55	-220
$6f_3$	1320	1155	990	825	660	495	330	165	0
$7f_3$	1540	1375	1210	1045	880	715	550	385	220
$8f_3$	1760	1595	1430	1265	1100	935	770	605	440

$f_4 - f_2$		f_2	$2f_2$	$3f_2$	$4f_2$	$5f_2$	$6f_2$	$7f_2$	$8f_2$
		165	330	495	660	825	990	1155	1320
f_4	275	110	-55	-220	-385	-550	-715	-880	-1045
$2f_4$	550	385	220	55	-110	-275	-440	-605	-770
$3f_4$	825	660	495	330	165	0	-165	-330	-495
$4f_4$	1100	935	770	605	440	275	110	-55	-220
$5f_4$	1375	1210	1045	880	715	550	385	220	55
$6f_4$	1650	1485	1320	1155	990	825	660	495	330
$7f_4$	1925	1760	1595	1430	1265	1100	935	770	605
$8f_4$	2200	2035	1870	1705	1540	1375	1210	1045	880

$f_4 - f_3$		f_3	$2f_3$	$3f_3$	$4f_3$	$5f_3$	$6f_3$	$7f_3$	$8f_3$
		220	440	660	880	1100	1320	1540	1760
f_4	275	55	-165	-385	-605	-825	-1045	-1265	-1485
$2f_4$	550	330	110	-110	-330	-550	-770	-990	-1210
$3f_4$	825	605	385	165	-55	-275	-495	-715	-935
$4f_4$	1100	880	660	440	220	0	-220	-440	-660
$5f_4$	1375	1155	935	715	495	275	55	-165	-385
$6f_4$	1650	1430	1210	990	770	550	330	110	-110
$7f_4$	1925	1705	1485	1265	1045	825	605	385	165
$8f_4$	2200	1980	1760	1540	1320	1100	880	660	440

$f_2 + f_1$		f_1	$2f_1$	$3f_1$	$4f_1$	$5f_1$	$6f_1$	$7f_1$	$8f_1$
		110	220	330	440	550	660	770	880
f_2	165	275	385	495	605	715	825	935	1045
$2f_2$	330	440	550	660	770	880	990	1100	1210
$3f_2$	495	605	715	825	935	1045	1155	1265	1375
$4f_2$	660	770	880	990	1100	1210	1320	1430	1540
$5f_2$	825	935	1045	1155	1265	1375	1485	1595	1705
$6f_2$	990	1100	1210	1320	1430	1540	1650	1760	1870
$7f_2$	1155	1265	1375	1485	1595	1705	1815	1925	2035
$8f_2$	1320	1430	1540	1650	1760	1870	1980	2090	2200

$f_3 + f_1$		f_1	$2f_1$	$3f_1$	$4f_1$	$5f_1$	$6f_1$	$7f_1$	$8f_1$
		110	220	330	440	550	660	770	880
f_3	220	330	440	550	660	770	880	990	1100
$2f_3$	440	550	660	770	880	990	1100	1210	1320
$3f_3$	660	770	880	990	1100	1210	1320	1430	1540
$4f_3$	880	990	1100	1210	1320	1430	1540	1650	1760
$5f_3$	1100	1210	1320	1430	1540	1650	1760	1870	1980
$6f_3$	1320	1430	1540	1650	1760	1870	1980	2090	2200
$7f_3$	1540	1650	1760	1870	1980	2090	2200	2310	2420
$8f_3$	1760	1870	1980	2090	2200	2310	2420	2530	2640

$f_4 + f_1$		f_1	$2f_1$	$3f_1$	$4f_1$	$5f_1$	$6f_1$	$7f_1$	$8f_1$
		110	220	330	440	550	660	770	880
f_4	275	385	495	605	715	825	935	1045	1155
$2f_4$	550	660	770	880	990	1100	1210	1320	1430
$3f_4$	825	935	1045	1155	1265	1375	1485	1595	1705
$4f_4$	1100	1210	1320	1430	1540	1650	1760	1870	1980
$5f_4$	1375	1485	1595	1705	1815	1925	2035	2145	2255
$6f_4$	1650	1760	1870	1980	2090	2200	2310	2420	2530
$7f_4$	1925	2035	2145	2255	2365	2475	2585	2695	2805
$8f_4$	2200	2310	2420	2530	2640	2750	2860	2970	3080

$f_3 + f_2$		f_2	$2f_2$	$3f_2$	$4f_2$	$5f_2$	$6f_2$	$7f_2$	$8f_2$
		165	330	495	660	825	990	1155	1320
f_3	220	385	550	715	880	1045	1210	1375	1540
$2f_3$	440	605	770	935	1100	1265	1430	1595	1760
$3f_3$	660	825	990	1155	1320	1485	1650	1815	1980
$4f_3$	880	1045	1210	1375	1540	1705	1870	2035	2200
$5f_3$	1100	1265	1430	1595	1760	1925	2090	2255	2420
$6f_3$	1320	1485	1650	1815	1980	2145	2310	2475	2640
$7f_3$	1540	1705	1870	2035	2200	2365	2530	2695	2860
$8f_3$	1760	1925	2090	2255	2420	2585	2750	2915	3080

$f_4 + f_2$		f_2	$2f_2$	$3f_2$	$4f_2$	$5f_2$	$6f_2$	$7f_2$	$8f_2$
		165	330	495	660	825	990	1155	1320
f_4	275	440	605	770	935	1100	1265	1430	1595
$2f_4$	550	715	880	1045	1210	1375	1540	1705	1870
$3f_4$	825	990	1155	1320	1485	1650	1815	1980	2145
$4f_4$	1100	1265	1430	1595	1760	1925	2090	2255	2420
$5f_4$	1375	1540	1705	1870	2035	2200	2365	2530	2695
$6f_4$	1650	1815	1980	2145	2310	2475	2640	2805	2970
$7f_4$	1925	2090	2255	2420	2585	2750	2915	3080	3245
$8f_4$	2200	2365	2530	2695	2860	3025	3190	3355	3520

$f_4 + f_3$		f_3	$2f_3$	$3f_3$	$4f_3$	$5f_3$	$6f_3$	$7f_3$	$8f_3$
		220	440	660	880	1100	1320	1540	1760
f_4	275	495	715	935	1155	1375	1595	1815	2035
$2f_4$	550	770	990	1210	1430	1650	1870	2090	2310
$3f_4$	825	1045	1265	1485	1705	1925	2145	2365	2585
$4f_4$	1100	1320	1540	1760	1980	2200	2420	2640	2860
$5f_4$	1375	1595	1815	2035	2255	2475	2695	2915	3135
$6f_4$	1650	1870	2090	2310	2530	2750	2970	3190	3410
$7f_4$	1925	2145	2365	2585	2805	3025	3245	3465	3685
$8f_4$	2200	2420	2640	2860	3080	3300	3520	3740	3960

Appendix II

Some combination tones of the A-major triad with equal-tempered intervals

f_2-f_1		f_1	$2f_1$	$3f_1$	$4f_1$	$5f_1$	$6f_1$	$7f_1$	$8f_1$
		110	220	330	440	550	660	770	880
f_2	165,82	55,82	-54,18	-164,18	-274,18	-384,18	-494,18	-604,18	-714,18
$2f_2$	331,64	221,64	111,64	1,64	-108,36	-218,36	-328,36	-438,36	-548,36
$3f_2$	497,46	387,46	277,46	167,46	57,46	-52,54	-162,54	-272,54	-382,54
$4f_2$	663,28	553,28	443,28	333,28	223,28	113,28	3,28	-106,72	-216,72
$5f_2$	829,1	719,1	609,1	499,1	389,1	279,1	169,1	59,1	-50,9
$6f_2$	994,92	884,92	774,92	664,92	554,92	444,92	334,92	224,92	114,92
$7f_2$	1160,74	1050,74	940,74	830,74	720,74	610,74	500,74	390,74	280,74
$8f_2$	1326,56	1216,56	1106,56	996,56	886,56	776,56	666,56	556,56	446,56

f_3-f_1		f_1	$2f_1$	$3f_1$	$4f_1$	$5f_1$	$6f_1$	$7f_1$	$8f_1$
		110	220	330	440	550	660	770	880
f_3	220	110	0	-110	-220	-330	-440	-550	-660
$2f_3$	440	330	220	110	0	-110	-220	-330	-440
$3f_3$	660	550	440	330	220	110	0	-110	-220
$4f_3$	880	770	660	550	440	330	220	110	0
$5f_3$	1100	990	880	770	660	550	440	330	220
$6f_3$	1320	1210	1100	990	880	770	660	550	440
$7f_3$	1540	1430	1320	1210	1100	990	880	770	660
$8f_3$	1760	1650	1540	1430	1320	1210	1100	990	880

f_4-f_1		f_1	$2f_1$	$3f_1$	$4f_1$	$5f_1$	$6f_1$	$7f_1$	$8f_1$
		110	220	330	440	550	660	770	880
f_4	277	167	57	-53	-163	-273	-383	-493	-603
$2f_4$	554	444	334	224	114	4	-106	-216	-326
$3f_4$	831	721	611	501	391	281	171	61	-49
$4f_4$	1108	998	888	778	668	558	448	338	228
$5f_4$	1385	1275	1165	1055	945	835	725	615	505
$6f_4$	1662	1552	1442	1332	1222	1112	1002	892	782
$7f_4$	1939	1829	1719	1609	1499	1389	1279	1169	1059
$8f_4$	2216	2106	1996	1886	1776	1666	1556	1446	1336

f_3-f_2		f_2	$2f_2$	$3f_2$	$4f_2$	$5f_2$	$6f_2$	$7f_2$	$8f_2$
		164,82	329,64	494,46	659,28	824,1	988,92	1153,74	1318,56
f_3	220	55,18	-109,64	-274,46	-439,28	-604,1	-768,92	-933,74	-1098,56
$2f_3$	440	275,18	110,36	-54,46	-219,28	-384,1	-548,92	-713,74	-878,56
$3f_3$	660	495,18	330,36	165,54	0,72	-164,1	-328,92	-493,74	-658,56
$4f_3$	880	715,18	550,36	385,54	220,72	55,9	-108,92	-273,74	-438,56
$5f_3$	1100	935,18	770,36	605,54	440,72	275,9	111,08	-53,74	-218,56
$6f_3$	1320	1155,18	990,36	825,54	660,72	495,9	331,08	166,26	1,44
$7f_3$	1540	1375,18	1210,36	1045,54	880,72	715,9	551,08	386,26	221,44
$8f_3$	1760	1595,18	1430,36	1265,54	1100,72	935,9	771,08	606,26	441,44

$f_4 - f_2$		f_2	$2f_2$	$3f_2$	$4f_2$	$5f_2$	$6f_2$	$7f_2$	$8f_2$
		164,82	329,64	494,46	659,28	824,1	988,92	1153,74	1318,56
f_4	277	112,18	-52,64	-217,46	-382,28	-547,1	-711,92	-876,74	-1041,56
$2f_4$	554	389,18	224,36	59,54	-105,28	-270,1	-434,92	-599,74	-764,56
$3f_4$	831	666,18	501,36	336,54	171,72	6,9	-157,92	-322,74	-487,56
$4f_4$	1108	943,18	778,36	613,54	448,72	283,9	119,08	-45,74	-210,56
$5f_4$	1385	1220,18	1055,36	890,54	725,72	560,9	396,08	231,26	66,44
$6f_4$	1662	1497,18	1332,36	1167,54	1002,72	837,9	673,08	508,26	343,44
$7f_4$	1939	1774,18	1609,36	1444,54	1279,72	1114,9	950,08	785,26	620,44
$8f_4$	2216	2051,18	1886,36	1721,54	1556,72	1391,9	1227,08	1062,26	897,44

$f_4 - f_3$		f_3	$2f_3$	$3f_3$	$4f_3$	$5f_3$	$6f_3$	$7f_3$	$8f_3$
		220	440	660	880	1100	1320	1540	1760
f_4	277	57	-163	-383	-603	-823	-1043	-1263	-1483
$2f_4$	554	334	114	-106	-326	-546	-766	-986	-1206
$3f_4$	831	611	391	171	-49	-269	-489	-709	-929
$4f_4$	1108	888	668	448	228	8	-212	-432	-652
$5f_4$	1385	1165	945	725	505	285	65	-155	-375
$6f_4$	1662	1442	1222	1002	782	562	342	122	-98
$7f_4$	1939	1719	1499	1279	1059	839	619	399	179
$8f_4$	2216	1996	1776	1556	1336	1116	896	676	456

$f_2 + f_1$		f_1	$2f_1$	$3f_1$	$4f_1$	$5f_1$	$6f_1$	$7f_1$	$8f_1$
		110	220	330	440	550	660	770	880
f_2	165,82	275,82	385,82	495,82	605,82	715,82	825,82	935,82	1045,82
$2f_2$	331,64	441,64	551,64	661,64	771,64	881,64	991,64	1101,64	1211,64
$3f_2$	497,46	607,46	717,46	827,46	937,46	1047,46	1157,46	1267,46	1377,46
$4f_2$	663,28	773,28	883,28	993,28	1103,28	1213,28	1323,28	1433,28	1543,28
$5f_2$	829,1	939,1	1049,1	1159,1	1269,1	1379,1	1489,1	1599,1	1709,1
$6f_2$	994,92	1104,92	1214,92	1324,92	1434,92	1544,92	1654,92	1764,92	1874,92
$7f_2$	1160,74	1270,74	1380,74	1490,74	1600,74	1710,74	1820,74	1930,74	2040,74
$8f_2$	1326,56	1436,56	1546,56	1656,56	1766,56	1876,56	1986,56	2096,56	2206,56

$f_3 + f_1$		f_1	$2f_1$	$3f_1$	$4f_1$	$5f_1$	$6f_1$	$7f_1$	$8f_1$
		110	220	330	440	550	660	770	880
f_3	220	330	440	550	660	770	880	990	1100
$2f_3$	440	550	660	770	880	990	1100	1210	1320
$3f_3$	660	770	880	990	1100	1210	1320	1430	1540
$4f_3$	880	990	1100	1210	1320	1430	1540	1650	1760
$5f_3$	1100	1210	1320	1430	1540	1650	1760	1870	1980
$6f_3$	1320	1430	1540	1650	1760	1870	1980	2090	2200
$7f_3$	1540	1650	1760	1870	1980	2090	2200	2310	2420
$8f_3$	1760	1870	1980	2090	2200	2310	2420	2530	2640

$f_{4+}f_1$		f_1	$2f_1$	$3f_1$	$4f_1$	$5f_1$	$6f_1$	$7f_1$	$8f_1$
		110	220	330	440	550	660	770	880
f_4	277	387	497	607	717	827	937	1047	1157
$2f_4$	554	664	774	884	994	1104	1214	1324	1434
$3f_4$	831	941	1051	1161	1271	1381	1491	1601	1711
$4f_4$	1108	1218	1328	1438	1548	1658	1768	1878	1988
$5f_4$	1385	1495	1605	1715	1825	1935	2045	2155	2265
$6f_4$	1662	1772	1882	1992	2102	2212	2322	2432	2542
$7f_4$	1939	2049	2159	2269	2379	2489	2599	2709	2819
$8f_4$	2216	2326	2436	2546	2656	2766	2876	2986	3096

$f_{3+}f_2$		f_2	$2f_2$	$3f_2$	$4f_2$	$5f_2$	$6f_2$	$7f_2$	$8f_2$
		164,82	329,64	494,46	659,28	824,1	988,92	1153,74	1318,56
f_3	220	384,82	549,64	714,46	879,28	1044,1	1208,92	1373,74	1538,56
$2f_3$	440	604,82	769,64	934,46	1099,28	1264,1	1428,92	1593,74	1758,56
$3f_3$	660	824,82	989,64	1154,46	1319,28	1484,1	1648,92	1813,74	1978,56
$4f_3$	880	1044,82	1209,64	1374,46	1539,28	1704,1	1868,92	2033,74	2198,56
$5f_3$	1100	1264,82	1429,64	1594,46	1759,28	1924,1	2088,92	2253,74	2418,56
$6f_3$	1320	1484,82	1649,64	1814,46	1979,28	2144,1	2308,92	2473,74	2638,56
$7f_3$	1540	1704,82	1869,64	2034,46	2199,28	2364,1	2528,92	2693,74	2858,56
$8f_3$	1760	1924,82	2089,64	2254,46	2419,28	2584,1	2748,92	2913,74	3078,56

$f_{4+}f_2$		f_2	$2f_2$	$3f_2$	$4f_2$	$5f_2$	$6f_2$	$7f_2$	$8f_2$
		164,82	329,64	494,46	659,28	824,1	988,92	1153,74	1318,56
f_4	277	441,82	606,64	771,46	936,28	1101,1	1265,92	1430,74	1595,56
$2f_4$	554	718,82	883,64	1048,46	1213,28	1378,1	1542,92	1707,74	1872,56
$3f_4$	831	995,82	1160,64	1325,46	1490,28	1655,1	1819,92	1984,74	2149,56
$4f_4$	1108	1272,82	1437,64	1602,46	1767,28	1932,1	2096,92	2261,74	2426,56
$5f_4$	1385	1549,82	1714,64	1879,46	2044,28	2209,1	2373,92	2538,74	2703,56
$6f_4$	1662	1826,82	1991,64	2156,46	2321,28	2486,1	2650,92	2815,74	2980,56
$7f_4$	1939	2103,82	2268,64	2433,46	2598,28	2763,1	2927,92	3092,74	3257,56
$8f_4$	2216	2380,82	2545,64	2710,46	2875,28	3040,1	3204,92	3369,74	3534,56

$f_{4+}f_3$		f_3	$2f_3$	$3f_3$	$4f_3$	$5f_3$	$6f_3$	$7f_3$	$8f_3$
		220	440	660	880	1100	1320	1540	1760
f_4	277	497	717	937	1157	1377	1597	1817	2037
$2f_4$	554	774	994	1214	1434	1654	1874	2094	2314
$3f_4$	831	1051	1271	1491	1711	1931	2151	2371	2591
$4f_4$	1108	1328	1548	1768	1988	2208	2428	2648	2868
$5f_4$	1385	1605	1825	2045	2265	2485	2705	2925	3145
$6f_4$	1662	1882	2102	2322	2542	2762	2982	3202	3422
$7f_4$	1939	2159	2379	2599	2819	3039	3259	3479	3699
$8f_4$	2216	2436	2656	2876	3096	3316	3536	3756	3976