

METRONOMIC PRECISION OF ›TEUTONIC METAL‹ A METHODOLOGICAL CHALLENGE FOR RHYTHM AND PERFORMANCE RESEARCH

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Introduction

In metal music, artists use various signifiers to affiliate themselves with distinct subgenres associated with specific geographical regions and their cultural characteristics. These signifiers are often purely visual, as it is the case with flags on album covers or, for example, mead horns and dresses worn on stage by Viking metal bands such as Amon Amarth. Furthermore, distinct timbres like oriental horns are used, such as in the music of the American extreme metal band Nile, a blend of death metal and the ancient soundscape of Egypt. While artists consciously choose these signifiers to create an image that may or may not resemble their own cultural background, other characteristics, such as the sense of rhythm and related performance attributes, are more authentically linked to the artist's musical background, as these are due to socialisation (Kallberg 2004).

This article is part of a larger research project on ›Teutonic‹ metal, which has previously investigated the production aesthetics of Teutonic metal versus American and British metal of the 1980s and 1990s by means of interviews with metal producers (Herbst 2019, 2021; Herbst & Bauerfeind 2021) and using a practice-led methodology (Herbst 2020). Creating three pastiche mixes of the same metal song in German, British, and American style has helped to audibly illustrate the cultural differences and production decisions involved. Idiosyncratic micro-rhythmic features of the individual styles could only be simulated rudimentarily by slightly moving the instruments on the time axis. Another aspect that could not yet be fully explored regards the widespread experience amongst producers that performances of early metal music from Germany differed from those of the

Anglo-American scene. While American and British musicians were inspired by Afro-American styles such as rhythm and blues, Teutonic musicians were rather influenced by the classical music canon and marching music (Herbst & Bauerfeind 2021). Due to this socialisation, German musicians had different expressive timing. Their performances were metronomically more precise, rigid, and synchronised than those of American and British musicians, whose ensemble performances were looser, had a higher degree of laid-back accentuation, and used ternary rhythms more frequently (Herbst 2019, 2021; Herbst & Bauerfeind 2021).

Rhythm and performance research has a long tradition. Most musicological studies have prioritised the Western art music canon (Gabrielsson 2003: 222) or jazz, blues, and soul music (Danielsen 2006, 2010a, 2010b, 2012, 2015). Metal music, with its fast tempo, rich instrumentation, high degree of distortion, dense textures, and compressed dynamic range, poses a particular challenge for rhythm research. It is therefore not surprising that only a few studies attempted to analyse *performed* rhythm on metal recordings (Hannan 2018; Lucas 2018); most stayed at the *compositional* level of sheet music (Pieslak 2007; Elflein 2010; Capuzzo 2018).

This study has three objectives: Firstly, to preliminarily investigate the aforementioned producers' theory of performative differences between German and Anglo-American metal by means of an exemplary analysis of songs. Secondly, to explore ways in which music production software can assist the analysis of recorded performances. Thirdly, to raise awareness of the role of music production and sound quality in rhythm research, thus highlighting that sonically dense and rhythmically fast genres like metal are particularly difficult to analyse. After an overview of rhythm research, the article deals with culture-specific performance characteristics to provide more detail on the qualities of ›Teutonic‹ metal as perceived by producers and in journalistic media. The following discussion of methods will develop an analytical toolkit consisting of processing techniques used in audio production to facilitate rhythm research in spectrally dense musical genres such as metal. Finally, five songs are analysed as examples, which represent the different performance styles of Great Britain (Iron Maiden's ›Fear of the Dark‹), the USA (Jag Panzer's ›Call of the Wild‹), and Germany (Running Wild's ›Black Hand Inn‹ and ›Powder and Iron‹; Torian's ›Fires Beyond the Sun‹) in the early to mid-1990s. Although this sample size is not sufficient to prove or disprove the producers' theory of performative characteristics, it is a starting point for further discussion and serves to explore the proposed analytical toolkit.

Overview of rhythm research and its methods

There are two main approaches to studying performance in rhythm research: The first approach focuses on tempo over the course of a song and requires the researcher to tap on a keyboard or electronic music device with a touch screen whilst listening to a recording (Cook 1995; Bowen 1996; Rink 2002). This results in a list of numbers that can be visualised in graphs and compared with other performances. Although this approach works well for large musical units, accuracy depends on the researcher's skills and the audio quality. Even if both are ensured, the method is not suitable for smaller units at the level of beats and sub-beats (Clarke 2004: 89). Despite its disadvantages, this approach has been popular with musicologists because of its ease of use and the ability to separate dynamics and tempo, which can be misleading in perception (Cook 2013: 143). The second approach uses a waveform editor to manually analyse note onsets by listening and annotating the waveform. This can be done with any instrument or any number of instruments, but it is difficult and tends to be time-consuming when the material is dense (Clarke 2004: 89). For studies dealing with rhythmic and performative features below the level of beats, waveform analysis is preferable, while the tapping approach is better suited to capture the experience of tempo (Cook 2013: 144f). The visual analysis of audio representations has the advantage that parameters such as dynamics and sound spectrum are displayed alongside tempo information (Cook 2013: 145). What both approaches have in common is that they extract values to explain performative styles or aesthetic principles based on tempo information which is »a uniquely salient performance parameter, synthesising or summarising multiple musical processes« (Cook 2013: 143).

Early rhythm studies of popular music focused on the phenomenon of ›swing‹, common in jazz, blues, and other soul-inspired genres (Prögler 1995; Ashley 2002; Friberg & Sundström 2002). More recent studies such as Danielsen's (2006, 2010a, 2010b, 2012, 2015) continued this research by focusing on one of the crucial parameters of popular music, the groove. »In groove music in particular, the space between the notes seems very important. It is as if the silence creates a tension that locks the groove: the gaps between the sounds create the groove as much as the sounds themselves do« (Danielsen 2006: 54). Micro-temporal variations are decisive for groove qualities and differ between genres (Danielsen 2010a: 1, 7). They lie in the region of a few milliseconds and become »just as important a parameter as, say, tone, pitch, or loudness« (Iyer 2002: 398). Such variations range within a spectrum of consciousness in which musicians are more

or less aware of nuances in musical timing, depending on musical socialisation. An empirical study by Bengtson et al. (1969) suggests that temporal variations are an unconscious part of the musical dialect of a tradition or culture. For example, in African music the »rhythm that might be considered the main beat of the music is not emphasised. We can say that the musicians play ›around‹ the beat, or that they play on the off-beat« (Chernoff 1979: 48f). In Western (art) music, in contrast, musicians intend to minimise asynchrony by strictly keeping to and emphasising a joint tempo. But even in the Western world, there are deviations from quantised and synchronised rhythmic events. Johansson (2010: 72f) shows that in Scandinavian folk music »slight variations and graduations in phrasing, timing and articulation are in fact crucial to identifying the style overall, as well as the subgenres within it, and to evaluating the quality of the performance«.

A common shortcoming in rhythm research is the lack of attention paid to the effects of sound quality on the experience of timing. Traditionally, rhythm and sound have been separated and investigated with different methods. Danielsen (2010a: 10), however, argues that in studying rhythm and timing »the impact of mediation and music-production processes become profound, because recording as well as post-production processes such as equalizing and mixing deeply affect how we hear rhythmic phenomena«. The sound quality of an instrument shaped by audio production techniques has several effects on perceived timing. Waveforms of the recordings of individual instruments can be drastically shaped, altering the clarity of the attack points, which may emphasise the sense of ensemble synchronisation in a ›tight performance‹ or add a certain amount of blurring to mask a lack of synchronisation. In popular music, most instruments, instrument groups, and the stereo sum are compressed. The attack time of the compressor is crucial for the transient information. Set to a fast time, the sound is most dynamically controlled, while the rhythmic timing information is reduced because the initial transients are attenuated in relation to the sustain parts of the signal (Figure 1). However, if the attack time is increased, the reduction in dynamic range is less pronounced, but the transients remain unaffected and emphasise the timing information by reducing the sustain portion of the envelope relative to the attack (Figure 2).

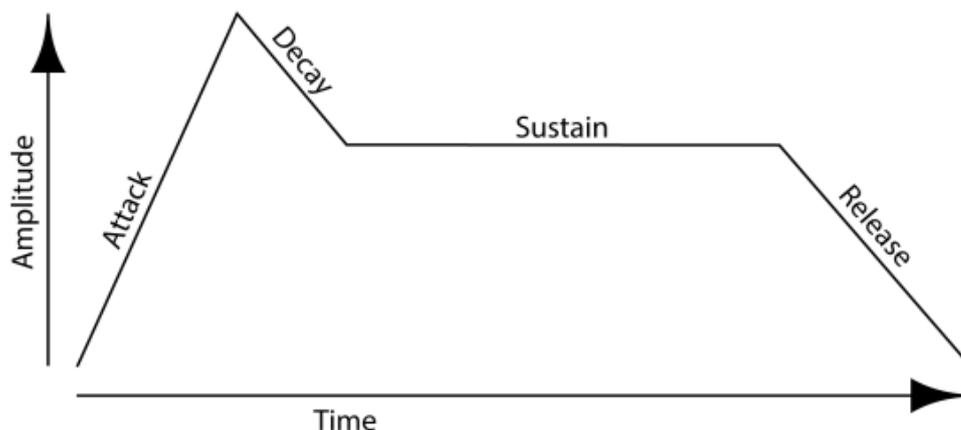


Figure 1: Envelope shape of an acoustic signal; the attack/decay phase relative to the sustain/release phase determines its percussiveness

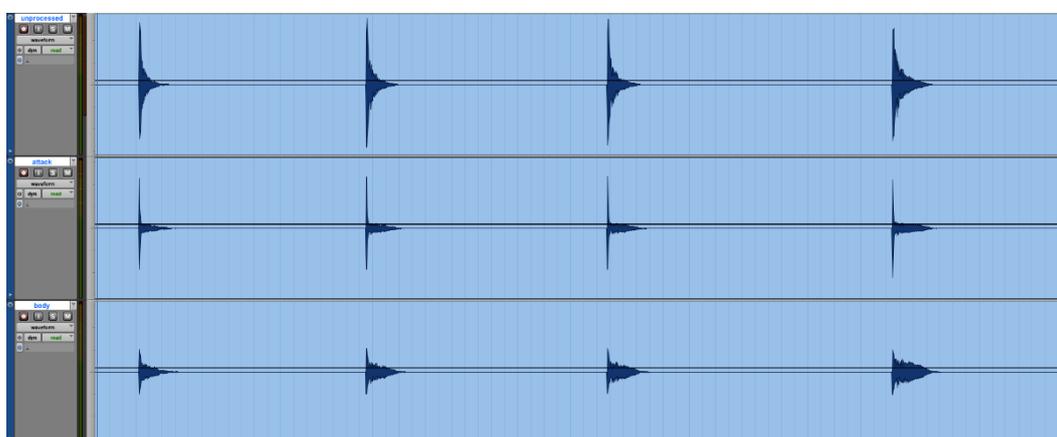


Figure 2: Waveforms of a snare drum. Top: original waveform; middle: slow compressor attack, emphasising the transients and reducing the body; bottom: fast compressor attack, emphasising the body and reducing the transients

The percussive qualities of recorded audio are further reduced by a limiter that imposes a threshold on the signal to increase the overall volume by eliminating the short spikes (»peaks«) in the attack phase. Every commercial song is limited at least on the final master, and often individual instruments are limited for the sake of consistent volume. Another common tool is a transient designer, which allows modifying attack and sustain qualities. Apart from these wave-shaping processors, equalisers and filters can also influence the rhythmic qualities, even if less drastically.

Danielsen acknowledged the importance of transients, for example in her micro-rhythm analysis of »Left and Right« (2000) by the American singer D'Angelo. Using the »metronome model«, which assumes a clear or correct placement of the internal beat, Danielsen determined the pulse discrepancy (»Inter Onset

Interval« or IOI) in the waveform editor of Apple's Logic Pro digital audio workstation (DAW). The method of visually extracting attack points from a waveform to measure note durations and distances between events allowed Danielsen to analyse the level of micro-rhythmic displacement of the snare compared to the bass and kick drum. The relevance of sound became apparent in the methodical challenge that »due to the dull sound of the bass drum, it remains unclear exactly where the bass/bass drum layer actually locates the internal beat« (Danielsen 2010b: 23). Manual analyses are afflicted with such problems, which could be overcome, as will be shown, by using music production techniques.

Culture-specific performances: Teutonic vs Anglo-American metal

The literature on ›classical‹ music holds references to national performance styles. For example, Lawson and Stowell (1999: 42) describe three »principal national idioms« during the baroque period—Italian, French, and German—which differed in virtuosity, precision, and severity. Dorian (1966: 179) states:

Tempo feeling is a quality common to all human beings. Yet, as the heartbeat varies in different persons, so the degree of tempo feeling differs from the individual to another. The sense of time varies with the age, the country, the race, the century. ... Today, the military march in Beethoven's *Fidelio*, in spite of its tempo instruction, *vivace*, might seem dull to an audience in Spain, where the scene of the opera is laid. An old Viennese waltz performed in the genuine slow *Laendler* tempo would probably seem maudlin to a modern American tap dancer.

Musical socialisation and role models influence the perception and practice of musicians. Kallberg (2004: 222) argues that cultural meanings are socially constructed: »To speak of the links between sound and culture, or of music as an expression of national ideals, it is necessary to view musical meaning as a social phenomenon shared by all participants in the sonic experience«. This emphasises the wider musical and socio-cultural context of the music, its performers, and audiences. Yet, as Cohen (1985) reminds us, societies and cultures are symbolically constructed; their characteristics are arbitrary, with dominant features deliberately shaped by hegemonic forces. Anderson (1983) similarly argues that societies are defined by myths of the past (›imagined community«). Consequently, ideas about the music of the past still influence the normative perception of what music from such an imagined community should be like. German metal is therefore perceived in the light

of past ›Teutonic music‹. Rigidity, severity, and stiff tempi became characteristic for many classical and romantic composers (Brown 1999: 382). Felix Mendelssohn was amongst the strongest proponents of this aesthetic, as his style was »characterized by quick, even tempos and imbued with what many people regarded as model logic and precision« (Ardoin 1994: 18). Stereotypical notions of German metal correspond exactly to these attributes.

There are several references to this performance characteristic in journalistic metal magazines. Many bands saw themselves in the tradition of classical music. For example, Udo Dirkschneider, singer of the proto-Teutonic metal band Accept, once stated: »A lot of German musicians use classical music as an influence. We're much closer to the classics. America is much closer to the blues. It's wrong for a German band to be like an American band. It's best to play and develop your own styles at all times« (Watts 1989: 38). For Accept guitarist Wolf Hoffmann, this classical influence was rather a result of his musical socialisation than a conscious decision (Poponina 2018). Abroad, classical composers like Brahms and Wagner were commonly referenced in reviews of early German metal musicians such as Helloween (Dome 1987a, 1987b; Russell 1987). Furthermore, the stereotype of precise playing is emphasised, as an interview by the German metal fanzine *Deaf Forever* with Night Demon shows: »German bands had this precision Accept or the Scorpions were so tight in their playing, that was the exact opposite of Motörhead or the early [Judas] Priest« (Kohsiek 2018: 37; translation).

In my previous research (Herbst 2019, 2020, 2021; Herbst & Bauerfeind 2021), I explored the performance idioms of Teutonic metal compared to metal from the USA and Great Britain based on interviews with metal producers. British Mark Mynett highlighted the »tight« and »very straight metronomic drum performances« of Teutonic metal bands in contrast to groups from English-speaking countries (Herbst 2019: 205f). German producer Siegfried Bemm agreed to this:

Many American productions are recorded live and are not quantised. This is a way of dealing with music that is completely different to what is done in Germany. Here everything has to be exact. Everything must fit. Micrometre calliper. »Hmm... the 16" tom could be a bit earlier...«. The English are more like the Americans. Much more open-minded and relaxed. The Irish are relaxed too. But the Germans are exact. (Herbst 2019: 217)

Proud to have a ›Teutonic signature‹, producer Karl Bauerfeind went even further and developed his own theory about the cultural differences between metal created by Central European and American bands, with the British resembling American groups (Herbst & Bauerfeind 2021). According to him, Teutonic musical culture was common in Central Europe because of its heritage

of ›classical‹ composers such as Bach, Mozart, and Beethoven, as well as of traditional marching music. He juxtaposed this heritage with Slavic cultures and the American continent with its African-influenced swing rhythms. As for the difference between Central Europe and America, Bauerfeind believed that the main reason was rhythmic feeling.

Why does an American band swing whereas a European doesn't? Because in America you count on two and four and in Germany it is one, two, three, four. This divides the two cultures, and this also shows in the drum performances. I know very few American drummers who can play Teutonic metal. ... Even excellent [American] drummers play laid-back, the snare slightly delayed. This doesn't work at all in Teutonic metal because the attack that the ear picks up first is the most important one. I don't want the snare to be masked by a kick drum hit ..., that's why the snare in my opinion has to be slightly ahead of the kick drum. This is preposterous to many American drummers and also hard for them to perform because they were trained to play laid-back. I've had real arguments with people. If the smallest element of a rhythmical unit is a sixteenth, then for me there is just one right way of placing the snare; right on one of the sixteenth. Why should it be laid-back? If I want this effect, I'll let the drummer know. Not many drummers comprehend this and are able to perform either way. One of those is Mikkey Dee [Motörhead, Don Dokken, King Diamond, Scorpions]. He sits down and asks you how I want it. ›Do you want me to play in European or American style?‹ He is even capable of gradually morphing one style into the other. At the very European end, the drums are perfectly aligned, that's how I want it. Then it's Teutonic metal. (Herbst 2021)

The alignment of the drum instruments and synchronisation with all accompanying instruments was crucial and had to be perfect to achieve the precise Teutonic sound. For Bauerfeind, these attributes trace back to Prussian military music, which is ›absolutely precise, ordered and musically aligned to facilitate marching in lockstep‹ (Herbst & Bauerfeind 2021). However, he emphasised that the ›precise alignment concept‹ and the high degree of ensemble synchronisation should not be confused with quantisation, the mapping of all events on a metric grid. Although instruments are usually mapped on a grid in Teutonic metal, the performer must ensure strict alignment between instruments, especially within the drum kit. Therefore, alignment rather depends on the player's feeling and skills than on editing (Herbst & Bauerfeind 2021).

According to producer interviews, the different metric emphasis—on the backbeat in American and British metal and on the main beats one and three or all beats of a bar in Teutonic metal—also extended to the sounds of the drum instruments. Unlike in British productions, where the drums were tuned higher,

and the snare was mixed most prominently to mark the backbeat—even more so in the USA—the drum shells in Teutonic metal were tuned low, and in the mix, the kick was louder than the snare (Herbst 2019, 2020, 2021; Herbst & Bauerfeind 2021).

Technological innovations have enormously influenced metal music production and the creation of artificial performances. In 2000, the standard industry DAW Pro Tools introduced the ›Beat Detective‹, a quantisation tool that allows producers to align audio recordings on a grid by separating, moving, and cross-fading regions with little to no artefacts (Thornton 2018). This simplified the quantisation of drum performances, a task that previously required tedious manual editing. Moreover, the editing functions became more powerful and made it easy to control performative elements of a band (Zagorski-Thomas 2014: 62). Thus, the result resembled a product constructed by the producer rather than a remotely truthful representation of a documented performance. It took a while before producers and artists recorded to a click track to be quantised, for example, American Machine Head and Slayer, produced by Matt Hyde (Mynett 2017: 32f). Not so German metal bands: Most of them embraced this new technology right away (Herbst 2021). However, as Thomas's (2015) research shows, metal productions today are characterised by clinically precise performances. In the words of producer Martyn Ford: »It is machine like, but that's how modern metal sort of is now. Setting up a whole band and capturing it as it is. In metal you don't do that« (Thomas 2015: 203). Most affected are the drum performances, which means that »such unnatural drum sounds ... could easily be mistaken for having been programmed« (Mynett 2017: 35).

Methods of analysis

The previous methodological review for art and popular music suggested that a combination of visual and auditory analysis is necessary to study micro-rhythm in performances. It also revealed that these two forms of music differ in their production aesthetic.

Programs such as Sonic Visualiser accommodate a range of algorithmic plugins that detect note onsets automatically, for instance through identifying changes in spectral energy. ... With modern recordings the results can be quite clean, often requiring little more than a quick check and interpretation of events such as hand breaking. (Cook 2013: 147)

Cook's conclusion reflects Western art music, especially piano solo pieces in which it is easy to map the listening experience to visual representations or to extract necessary information computationally. The arrangement is sparse, and the technically improved recording quality facilitates the analysis. In contrast, arrangements in metal music are dense due to heavy distortion, high track counts, and the drastic reduction of dynamic range, blending the individual sources into a wall of sound (Mynett 2017). Besides, the fast tempos combined with sixteenth-note riffs in guitars and drums further complicate auditory and visual analysis. These features make metal music more difficult to analyse than many other genres of popular music. Figures 3 and 4 support this claim: While the waveforms (Figure 3) in D'Angelo's soul song »Left and Right« (2000) have distinct rhythmic accents, it is much more challenging to interpret the waveform of Running Wild's metal track »Black Hand Inn« (1994). This also applies to the spectrographic view (Figure 4), where it is difficult to isolate individual instruments and their micro-rhythmic relations due to the high degree of distortion and the dense arrangement.



Figure 3: Waveforms of D'Angelo's »Left and Right« (2000) and Running Wild's »Black Hand Inn« (1994)

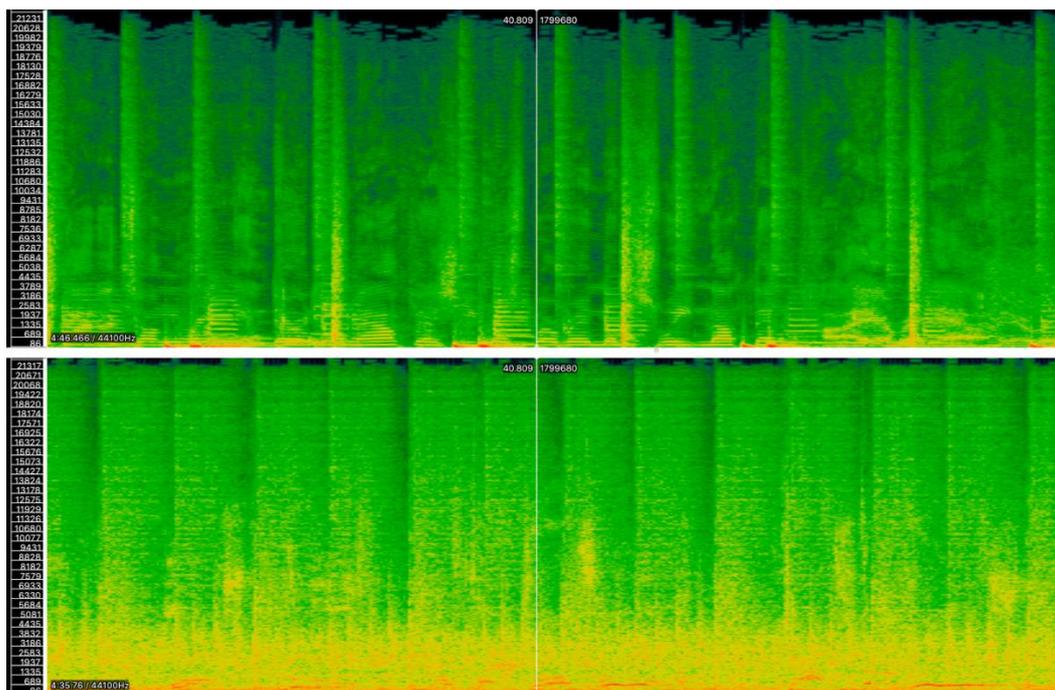


Figure 4: Spectrographs of D'Angelo's ›Left and Right◀ (2000) and Running Wild's ›Black Hand Inn◀ (1994)

One of the aims of this article is to explore as to how advanced music production software allows to dissect dense recordings and to extract information more easily. Modern DAWs and specialised plugins allow processing various areas of the stereo signal independently and offer the potential for audio separation rarely utilised in music analysis so far.

An effective way of isolating instruments is to mute the centre or side channels. For example, turning off the side channels exposes the lead vocal, bass, and the main drum instruments kick and snare. Muting the middle channel isolates the guitars and other accompanying instruments, drum overhead and room signals, and spatial effects such as the reverb used on lead instruments. Technically, channels can be isolated with special plugins such as Waves Center (Figure 5) or Brainworx Control (Figure 6). In Waves Center, the plugin's ›low◀ and ›high◀ controls allow attenuating or strengthening instruments on the respective channels for even greater isolation. As an alternative to specialised tools, the vol-

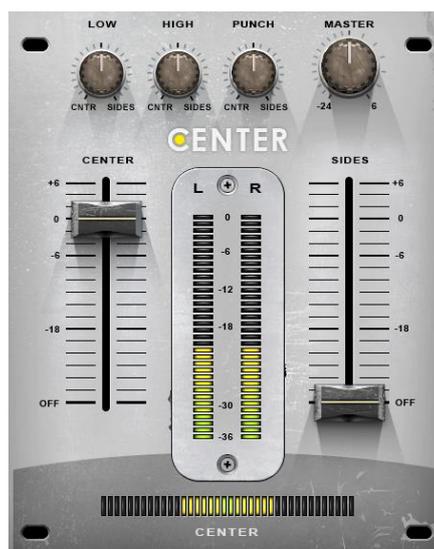


Figure 5: Muting the sides channel in Waves Center

ume of the centre and side channels can be reduced with a simple gain plugin in mid/side mode, which is included in most DAWs.



Figure 6: Brainworx Control allows soloing the middle and side channels either ›in place‹ or in the middle

Another way to remove the centre channel is »L minus R« by means of eliminating the left from the right channel or vice versa. Technically, the stereo recording is hereby split into its left and right channel, both panned to the centre, and the phase of one of the channels is reversed (Figure 7). For removing the middle information, this technique is better suited than most plugin solutions.

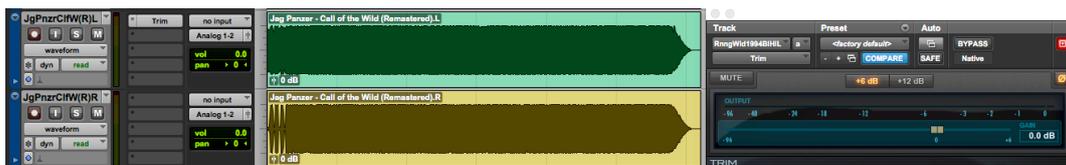


Figure 7: Removal of the centre channel using the L-R technique

Separating the centre and side channels simplifies auditory analysis, but the usefulness of visual analysis using waveform representations depends on genre production aesthetics. In metal music, this separation is less effective, as a visualisation of Iron Maiden's »Fear of the Dark« (1992) shows (Figure 8). The centre channel looks almost identical to the original. This is because it must contain the most important signals to be mono-compatible. The side channels contain rhythm guitars, drum cymbals, and vocal effects. Due to the inherent compression effect of distortion (Herbst 2017b), guitars do not have a wide dynamic range, which is reflected in the waveforms compared to the more percussive nature of the centre channel. The sides are dynamically flat; there are some transient spikes (peaks), but the body of the sound (RMS) is not conclusive for rhythm analysis.

In the spectrographic visualisation (Figure 9), the differences between the channels are clearer. The sides contain almost no drums except cymbals and quiet snare hits, while the centre shows kick, snare, bass, and vocals clearly with little interference from the guitars.

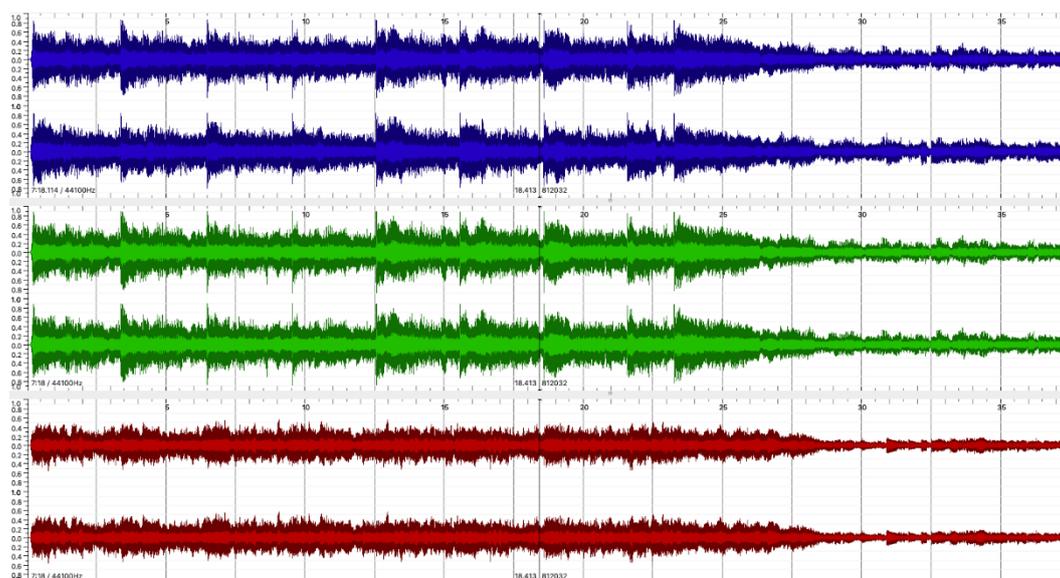


Figure 8: Waveforms of Iron Maiden's (1992) »Fear of the Dark«. Top: released version; middle: centre channel; bottom: side channels

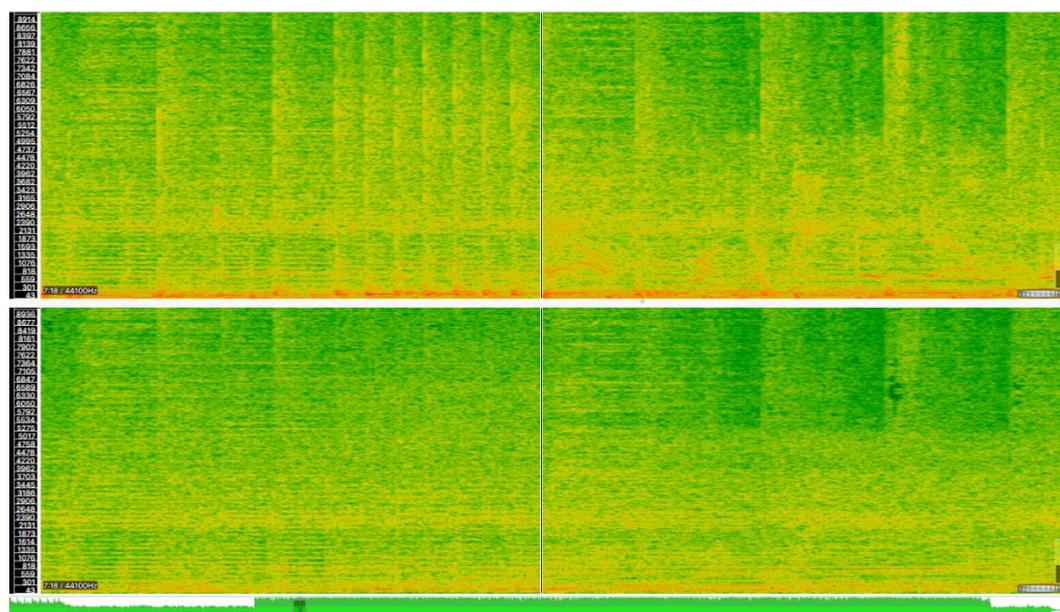


Figure 9: Beginning of the vocals in the first distorted part of Iron Maiden's (1992) »Fear of the Dark«. Top: centre channel; bottom: side channels

Other techniques to facilitate rhythmic analysis include transient designers that overemphasise the note onsets, making them clearer in a visual representation and easier to hear. Another technique that can be combined with any of the approaches is to artificially widen the stereo width. Doing so creates space between the instruments and makes them easier to identify. Sophisticated mastering tools such as Brainworx panEQ (Figure 10) even allow boosting frequencies anywhere in the stereo field to make instruments stick out.

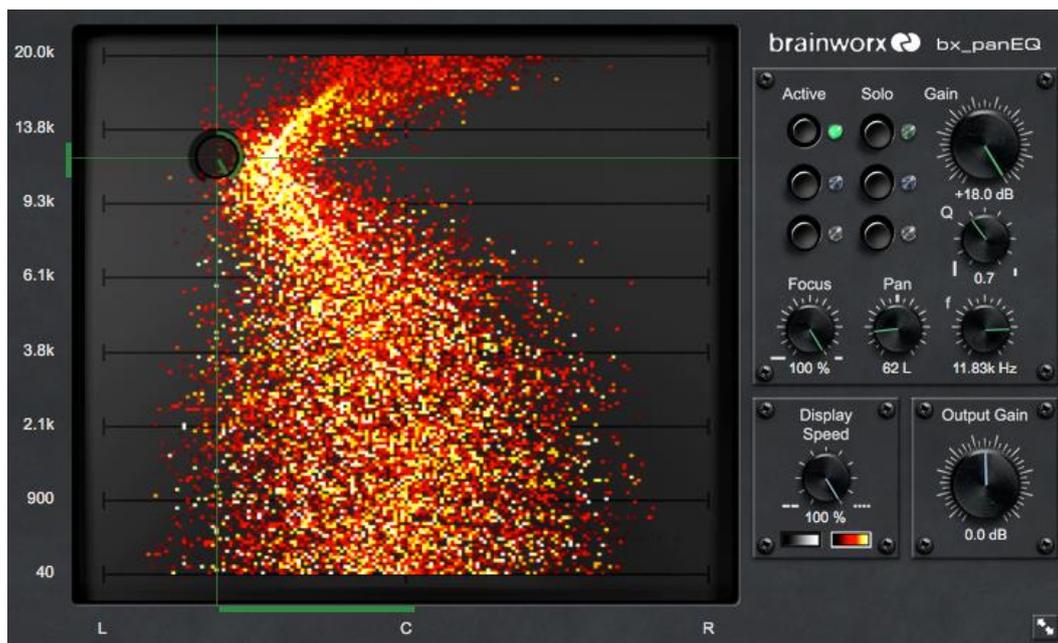


Figure 10: Example of the panEQ highlighting the attack transients of a ride cymbal in a full stereo mix



Figure 11: Isolating the bass guitar in the intro of Iron Maiden's »Fear of the Dark« (1992)

The centre and side information of the isolated instruments can further be improved by limiting the frequency range with filters to remove spectral content not part of the instrument's primary range (Figure 11). Besides, boosting certain frequencies to bring out instruments in a full arrangement also facilitates aural and visual analysis.

The following analysis examines the rhythmic properties of four heavy metal songs from the early to mid-1990s before Pro Tools' Beat Detective became available in the 2000s for the increased quantisation of metal productions. Songs from bands that are prototypical for the playing styles of their countries were selected as follows: Iron Maiden's ›Fear of the Dark‹ (1992), produced by Martin Birch, stands for British metal. For the USA, one of the oldest heavy/power metal bands in the country, Jag Panzer (›Call of the Wild‹, 1997), was chosen. The album was produced by Jim Morris. German metal is represented by Running Wild (›Black Hand Inn‹ and ›Powder and Iron‹, 1994), who are the most ›Teutonic‹ band their producer Bauerfeind has ever worked with (Herbst & Bauerfeind 2021). A fifth song (German Torian's ›Fires Beyond the Sun‹, 2012) serves as a control track; it was produced by me with a drum computer instead of live drums. This allows comparing micro-rhythm of real musicians with a machine and testing the proposed analytical toolkit with access to multi-track files.

Analysis

Rhythm research traditionally utilised tempo maps to capture the more general experience of song tempo and waveform analysis to study micro-temporal variations. Following these conventions, this analysis further explores alternatives to manual tempo tapping by the researcher. Many modern DAWs support automatic tempo-mapping based on transient information. For this project, the tempo mapping algorithms of Apple Logic Pro 10.4.8, Avid Pro Tools 2019.6.0, and Steinberg Cubase 10.5 were compared. Logic Pro created the most accurate maps on a song level. Figure 12 displays the tempo maps in an automatic rhythmic resolution of four of the five tracks. From listening impressions, the tempo maps of ›Fear of the Dark‹ and ›Call of the Wild‹ were very accurate, ›Fires Beyond the Sun‹ was still accurate, and ›Black Hand Inn‹ relatively accurate. The denser the sound of the production, the less accurate the result.

As the maps indicate, ›Fear of the Dark‹ does not have a constant tempo but varies between form parts, corresponding to the listening impression. Iron Maiden are known for not recording to a click track (Daniels 2012: 182), and parts of this song are played in different tempi, which is reflected in the tempo map. It is not known whether Jag Panzer recorded to a metronome, but listening impression suggests this. The ending has an artificial effect of a tape reel slowing down. Running Wild recorded to a click, as their producer confirmed.

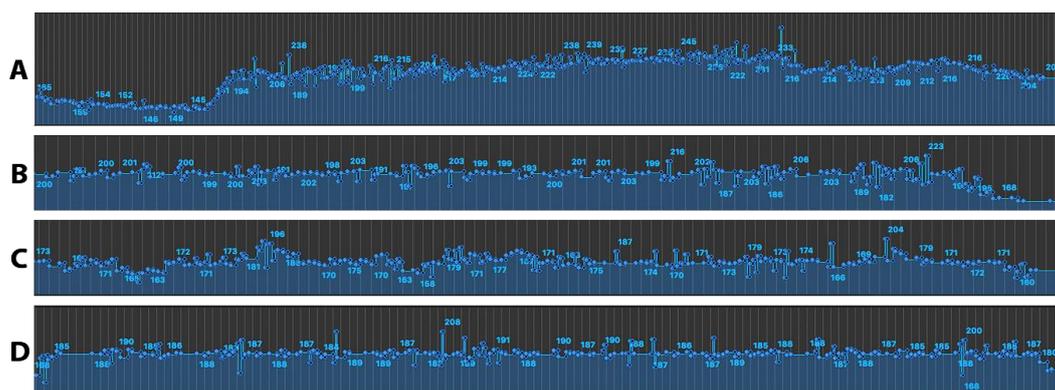


Figure 12: Tempo maps of »Fear of the Dark« (A), »Call of the Wild« (B), »Black Hand Inn« (C), and »Fires Beyond the Sun« (D)

Despite the use of click tracks and drum computers, all four tracks show some irregularity in their tempo maps, which can be explained by a combination of computer detection errors and performative features such as accentuation, rhythmic displacement, or unintended variation. To quantify the visual data, the individual tempo points were extracted as numerical data. Exporting such data is not possible with any DAW and required a workaround. The tempo maps were exported as MIDI files and imported into the freeware software MidiKit, which allowed copying the data to a spreadsheet. Table 1 gives an overview of the standard tempo deviation for automatic extraction and manual tapping at two resolutions for the latter. For the songs »Fear of the Dark« and »Call of the Wild«, the validity of the extraction is limited due to the tempo modulations. The large number of measurement points, however, averages the tempo modulations, at least for »Call of the Wild«. As far as the difference between the countries is concerned, the two German tracks indeed seem to be more rigid in tempo than »Call of the Wild«, the only reference track without deliberate, drastic tempo modulations. In terms of methodology, automatic detection resulted in a significantly larger number of measurement points, yet not necessarily in a higher standard deviation than manual capture. Furthermore, various predefined rhythmic resolutions worked well for some tracks with automatic detection.¹ For example, in »Fear of the Dark« a beat-based detection was predominantly accurate, while a bar-based resolution was not, due to the high temporal variation even within the form parts. »Call of the Wild« was accurate with automatic detection in both bars and beats mode. For »Black Hand Inn« and »Fires Beyond the Sun«, the rhythmically most complex and sonically most dense tracks, no predefined rhythmic resolution worked in the automatic analysis. Overall, given

¹ In Logic Pro, the »Smart Tempo« and »Beat Mapping« functions produce different results, so the best algorithm needs to be identified for each analysis.

the human inaccuracy observed in »Fires Beyond the Sun« with the drum computer, an automatic approach can achieve the same or even better results with less effort if the analysed material has a lower sonic density. The manual tapping errors are partly due to emotional excitement of experiencing the music and partly to the high tempi in metal music, shortcomings that can be avoided with automatic detection.

Table 1: Standard deviation of manual tapping approach in beats per minute at different resolutions

	»Fear of the Dark« (7:18 min.)	»Call of the Wild« (3:17 min.)	»Black Hand Inn« (4:36 min.)	»Fires Beyond the Sun« (5:28 min.)
SD (automatic)	25.9 (27,906)	9.5 (11,928)	8.7 (14,912)	5.7 (14,144)
SD beat (manual)	30.9 (1,412)	14.4 (622)	3.5 (762)	4.1 (1,012)
SD bar (manual)	30.5 (354)	13.5 (156)	1.4 (192)	1.7 (376)

Note: Numbers in parentheses indicate the number of measured tempo points

Several producers stated that rhythmic quantisation is particularly characteristic for Teutonic productions (Herbst 2019, 2021). But, according to Bauerfeind's theory (Herbst & Bauerfeind 2021), decisive for the different feels between Teutonic and Anglo-American metal is ensemble synchronisation, especially the alignment of the drum instruments in the micro-time domain. Tempo maps are not sufficient to determine synchronisation, as this requires both close listening and visual analysis, supported by waveform or spectrographic representations. With these songs, the spectrographic analysis was not even conclusive with the separated centre and side channels, so the best way to analyse micro-timing in this sonically dense and fast metal music was to apply the »metronome model« (Danielsen 2010b: 21-26) to the isolated, transient-shaped centre channel (with Waves Center plugin), which was analysed with Pro Tools' Beat Detective.

Figure 14 shows the main riff (Figure 13) of »Fear of the Dark« after the side channels were removed. To examine whether the drums play a constant tempo and whether the snare drum is played laid back in relation to the groove, the extract contains no vocals, and the bass has been attenuated as much as possible. The Beat Detective's transient markers are illustrated in purple. As the extracted tempo map shows, the tempo varies considerably, even in the short span of one or two bars, in accordance with the earlier tempo maps. The lack of time reference makes it impossible to analyse micro-timing by using Inter Offset Intervals

(IOI) or to compare the original with a quantised version as a means of performance analysis.

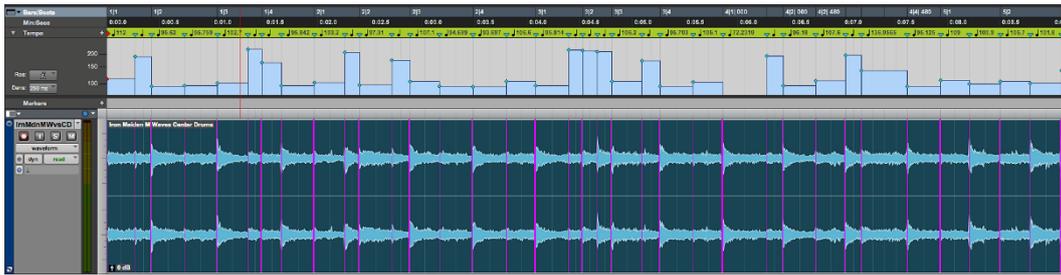


Figure 13: Main riff of »Fear of the Dark«

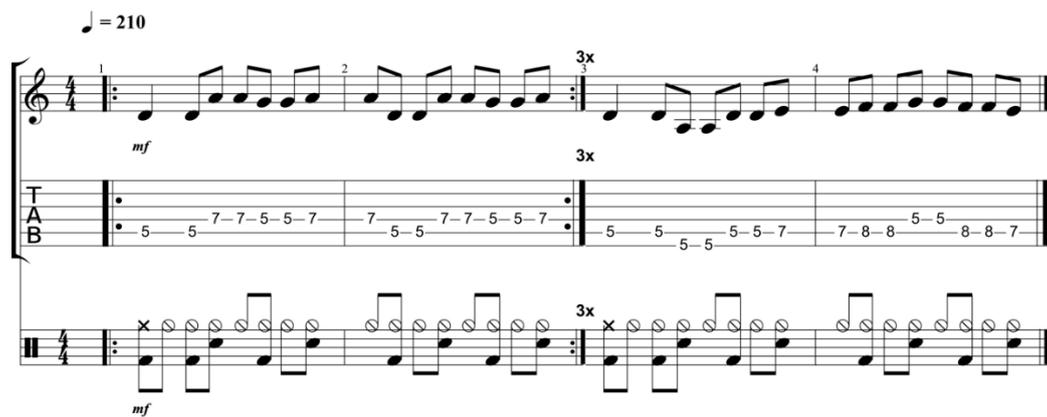


Figure 14: Main riff of »Fear of the Dark«; centre channel with transient markers; loud hits represent the snare drum

Another problem with visual analysis of rhythms is the relatively quiet volume of the kick compared to the snare drum, which according to producer Bauerfeind (Herbst 2019, 2021; Herbst & Bauerfeind 2021) is characteristic of British and American productions. Although it is possible to emphasise the fundamental frequency of the kick drum with an equaliser or sub-synthesiser, this also brings out the sustained bass instrument, which masks the rhythmic kick drum. One way around this problem is to use a transient designer that emphasises the rhythmic impulses in a waveform. While this processing does not change the software's transient recognition, it does simplify visual analysis (Figure 15). If the waveform of the side channels were extracted and placed on an adjacent track, the time relation between drums and bass on the centre channel and the guitars on the side channels could be compared. However, in accordance with the explanation in the previous methods section, this would not work for the songs in this study, as no clear attack points

could be analysed due to the distorted characteristics of the guitar in metal (Herbst 2017a).

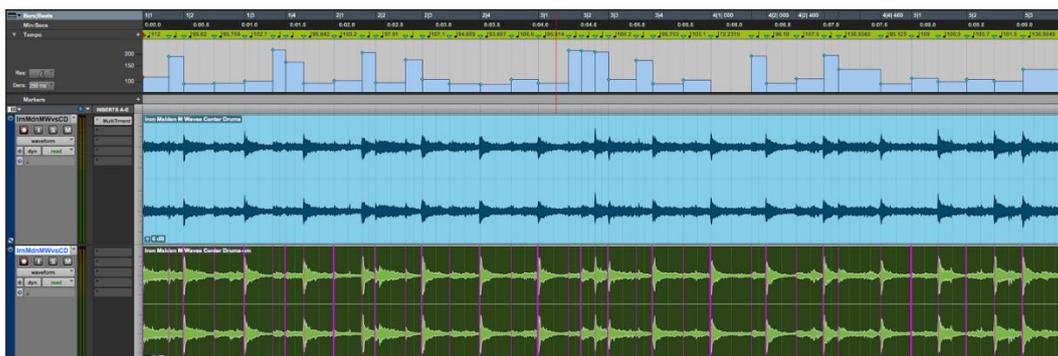


Figure 15: Main instrumental riff of »Fear of the Dark«. Top: unprocessed waveform; bottom: waveform processed with transient designer

From listening impression, the drums of »Fear of the Dark« are played slightly laid-back in the band performance. The guitars seem to be articulated ahead of the drums for the »pushy« feel of the riff. The bass follows the drums and is therefore located behind the guitars. Furthermore, the internal synchronisation of the drum kit seems to have the characteristic laid-back snare in line with the theory. As described, the degree of rhythmic displacement cannot be measured due to the absence of a fixed reference tempo, but the trained listener can recognise it. According to Clarke (1989), listeners can distinguish micro-rhythmic variation starting from about 30 to 50 ms. In »Fear of the Dark«, the snare is probably about 20 to 30 ms behind its »expected« position on the grid, which gives Iron Maiden their characteristic groove and confirms the theory about British metal.² This degree of laid-back phrasing and rhythmic discrepancy is lower than in soul music, as Danielsen's research shows. The dislocation in D'Angelo's »Left and Right« at a tempo of 92 bpm was about 70 to 85 ms (Danielsen 2010b) and in James Brown's »Sex Machine« at a tempo of 106 bpm about 90 ms (Danielsen 2012). This difference can be explained by the higher tempo of »Fear of the Dark« and the less intended shuffle rhythm in the metal genre.

American Jag Panzer's »Call of the Wild« appears to have been recorded to a click track at 200 bpm. An extract from the instrumental intro (Figure 16) was reduced to the centre channel, and the rhythmic qualities were emphasised with a transient designer (Figure 17).

2 This effect is even stronger in the clean form parts (e.g., 0:27-0:51): the lead guitar is phrased so far behind the rhythm guitar that both almost define individual tempi.

$\text{♩} = 200$

Figure 16: Instrumental intro of »Call of the Wild«



Figure 17: Instrumental intro of »Call of the Wild«; eighth-note rhythm at 200 bpm. Top: untreated centre channel; middle: transient designer; bottom: quantisation with Beat Detective

To analyse the micro-timing, the transient-enhanced waveform was compared with a copy quantised with the Beat Detective. The quantised violet track shows some deviations from the unquantised green track. Interestingly, all snare sounds (the louder and longer hits) in the unquantised version are played directly on the grid, but the kick drum is either intentionally played laid-back, or the drummer does not manage to play it accurately at this tempo. Aural comparison between the quantised and the unquantised version suggests that the micro-rhythmic deviations do not create an intentional feel

because the quantised version sounds as it was probably meant to be. Regarding the underlying theory, this indicates that the American Jag Panzer tried to play to the metronome as best as possible. It is unclear to what extent the performances have already been edited, but the intention of a quantised performance is obvious; yet, the Beat Detective was not available at the time of production. Regardless of the technical realisation, the performance has no laid-back elements and therefore does not correspond to the theory. This is different from the snare that, confirming to theory, is much more prominent than the kick drum, hence emphasising the backbeat.

On a methodological note, cutting the track on the transient markers, which can be done automatically with the Beat Detective, results in separate regions for each note. Afterwards, the exact length of each rhythm can be retrieved from the length of the region (Figure 18). This approach of generating IOIs is more accurate than manually measuring lengths on a waveform, which is what Danielsen (2010b) did in her previous research.

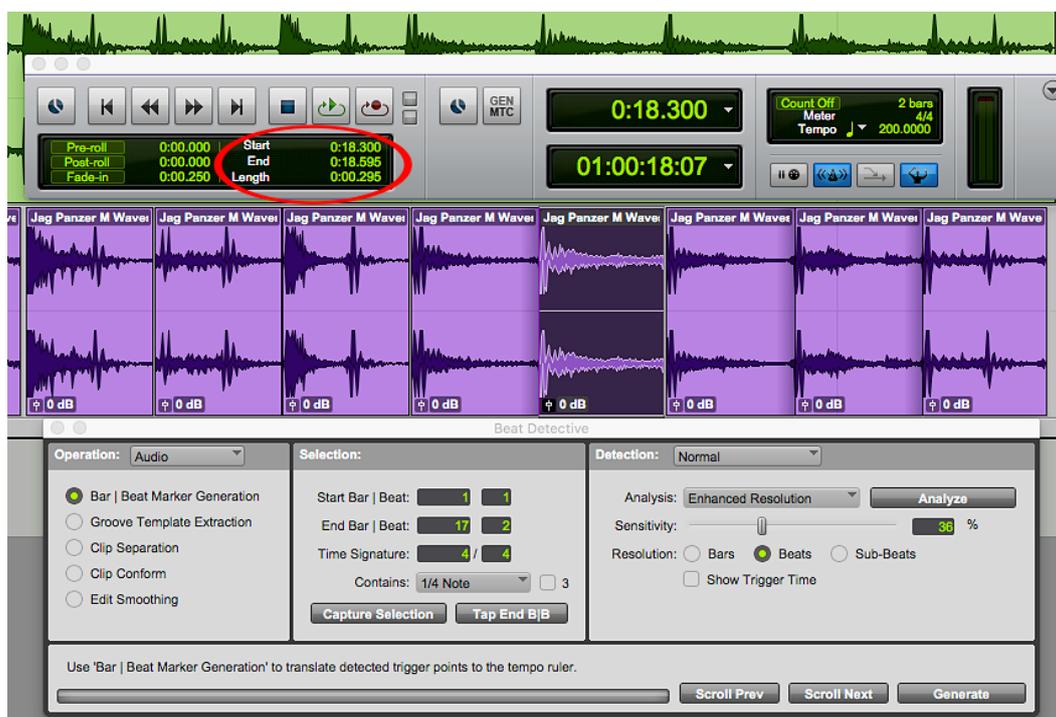


Figure 18: Retrieving the length of a rhythm note (Length: 295 ms) in the transport window (top); control window of the Beat Detective (bottom)

The micro-rhythmic characteristics of Running Wild's »Black Hand Inn« were impossible to analyse even with the production tools. The sound was too dense to separate the elements, and various guitars were partially on the centre channel, masking the drums. Little information could be retrieved from the waveform view, and the Beat Detective could not detect markers

correctly. Despite dating back to 1994, this song has the most contemporary metal sound and is evidence of the challenges of analysing rhythms on modern metal recordings. Instead of »Black Hand Inn«, »Powder and Iron« from the same album was analysed (Figure 20). The intro section (Figure 19) shows that although a lead guitar is on the centre channel, the drum hits are clearly visible in the waveform after being emphasised with a transient designer. The Beat Detective suggests some possibilities to adjust the drum performance closer to the underlying grid, but the deviations are minimal considering that the grid shown is in sixteenth notes at a relatively fast tempo of 154 bpm. This is the only song where there is a constant sixteenth-note double kick drum, which is considerably more difficult to play than the drums in »Fear of the Dark« and »Call of the Wild«. The slight deviations from the grid at this high tempo show an extremely accurate performance by the German band, in accordance with the underlying theory. Moreover, quantisation is only one part of the Teutonic aesthetic; the other is the synchronisation between the instruments and alignment of the drum instruments. From listening impression, both Running Wild songs are more synchronised and aligned than the two British and American examples. However, this cannot be proven objectively with waveforms or spectrograms without access to the individual recorded tracks. As far as the relative volume of kick and snare is concerned, the loud hits in the waveform should not be confused with the snare drum, as they are the double kick. This visual indication confirms the listening impression that the kick is louder than the snare. The kick, characteristic in Teutonic metal, emphasises the four main beats in a bar, as opposed to the accentuated backbeat in American and British productions, which supports the theory.

♩ = 154

The musical score for the instrumental intro of »Powder and Iron« is presented in three staves. The top staff is a lead guitar line in treble clef, 4/4 time, with a key signature of one sharp (F#) and a dynamic marking of *mf*. It consists of a continuous sixteenth-note double kick pattern. The middle staff is a double bass line in standard guitar fretboard notation, showing fret numbers: 4, 2, 2, 2, 2, 2, 2, 4, 2, 2, 2, 2, 2, 2, 7, 5, 5, 5, 5, 5, 5, 2, 0, 0, 0, 0, 0, 0. The bottom staff is a drum line in standard notation, showing a double kick pattern. The score is marked with '4x' at the beginning and end of the section.

Figure 19: Instrumental intro of »Powder and Iron«

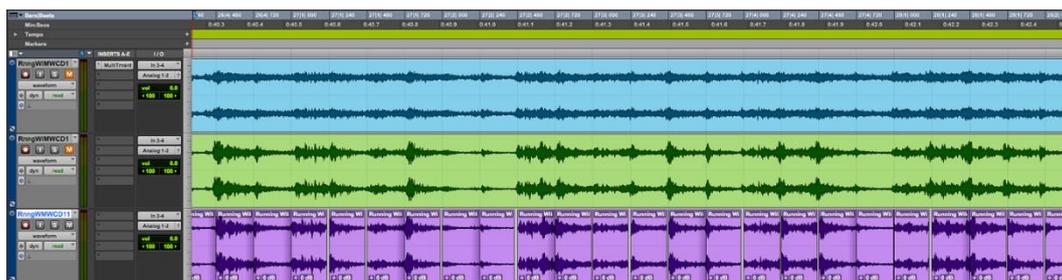


Figure 20: Instrumental intro of »Powder and Iron«; sixteenth note rhythm at 154 bpm. Top: untreated centre channel; middle: transient designed centre channel; bottom: quantisation with Beat Detective

»Fires Beyond the Sun« serves as a control song for the analysis method explored. The first two tracks in Figure 21 show the waveform of the original release and the isolated centre channel. Visually and aurally, there are no rhythm guitars in the middle channel. This suggests that in none of the other songs, the guitars are panned completely left and right. The stereo settings of the accompanying instruments therefore affect the quality of this mid/side isolation method. The third track shows the transient markers of the soloed drums exported from the original project. The waveform clearly correlates with the individual kick and snare on the two lower tracks. It is interesting that not all transient markers are on the grid, although the drum computer is fully quantised. The deviations are small and result from the interpretation of the envelope of each drum hit. These small deviations are an inherent problem of this method but can be solved by analysing smaller sections to adjust the Beat Detective settings, or by manually adjusting the markers to get the best result. As with the previous tempo maps, while the tools in a modern DAW provide high-quality extraction functions, manual fine-tuning is still essential. These tools support analysis but cannot replace human attention to detail, no matter how meticulously applied.



Figure 21: »Fires Beyond the Sun«. First track: original waveform; second track: centre channel only; third track: transient markers on the centre channel; fourth track: isolated kick; fifth track: isolated snare

Conclusion

Groove and sound are generally considered to be among the main qualities of popular music. Both are in a symbiotic relationship; music grooves better when the rhythmic qualities are supported by sound processing, and the sound is clearer and more effective when the instruments' rhythms are deliberately timed, especially in metal, where maximum power is achieved through performance precision and synchronisation. One of the intentions of this study was to raise awareness of the symbiotic role of groove and sound and to highlight many of the difficulties that arise in the analysis of micro-rhythm in metal music due to the production aesthetics of this genre, characterised by a dynamically limited and spectrally dense wall of sound. This aesthetic proved to be challenging in the analysis, and even with the help of advanced production tools, some problems could not be solved. Another aim of this study was to investigate how the processing functions of DAWs and specialised plugins can support both automated and manual rhythm and performance analysis. Not all of the discussed methods were necessary for the analysis, but the methods used did prove to be helpful. Of particular note is Pro Tools' Beat Detective, which has not been used in other performance research. Although not intended to be applied to full arrangements, with the proposed methods, it is still efficient if instruments are isolated. For songs with a static time reference, Beat Detective allows for visual comparison between the metronomically correct and the actual performances, and cutting the track at transient markers enables to extract Inter Onset Intervals (IOI) more accurately than is manually possible (see Danielsen 2010b). Such tools are used to quantise performances, so analysing quantisation with them in a 'reverse engineering' approach seems worthwhile.

The analytical toolkit was developed on the basis of observations by German and British metal producers and intended to support the analysis of performative and sonic differences between older metal music from Germany as well as America and Great Britain. Yet, no definite conclusions can be drawn from this study because of its small sample size, analytical limitations, idiosyncrasies of the bands and, not least, the risk of essentialism. Nevertheless, the findings tend to support the theory. The German performances were, despite their challenging requirements, more metronomic, synchronised, and aligned than the American and British performances. Iron Maiden corresponded most closely to the assumption of looser performances, not only due to their recording without a metronome. American Jag Panzer failed to meet expectations regarding laid-back play-

ing, yet featured, like Iron Maiden, loud snare and quiet kick drums—contrary to the German productions. Further research on the performative differences is necessary. To solve the described difficulties in analysing micro-rhythms in recorded metal, multi-tracks of productions from each of the countries would be needed. Access to the timing-corrected and, if possible, the originally recorded performances would help to better determine the rhythmic styles of playing and the processing involved to stage hyper-precision. However, since it is unrealistic that such sensitive material will be provided by bands or their producers, the most promising alternative for exploring performative differences between countries are still interviews with producers explaining their work with bands from various cultures.

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