Metal Music Studies
Volume 4 Number 3
 English language. doi: 10.1386/mms.4.3.481_1

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Guitar profiling technology in metal music production: Public reception, capability, consequences and perspectives

ABSTRACT

This empirical study explores the guitar profiling technology and its consequences for metal music production. After briefly introducing this technology, the article investigates its public reception in reviews and online discussion boards to explore the subjective perspectives. A subsequent acoustic experiment tests the capability of the technology. The findings show that many guitar players and producers have been highly sceptical of digital amplification technology because of tonal shortcomings. However, meanwhile many musicians seem convinced of profiling technology due to its good sound quality that has been confirmed by the experiment too. Since for most metal music genres the sound quality of the electric guitar is very

KEYWORDS

electric guitar
distortion
profiling technology
guitar players
music producers
future
psychology of music
music information retrieval

important, the creative practices and economic conditions of its production may likely be hugely affected by this technology. The article concludes by discussing the consequences of profiling technology regarding issues such as democratization of production tools, changes in professional services, creative potentials and future applications of the technology that may radically change metal music production.

Introduction

Metal is a genre highly depending on music technology on the levels of musical instruments, live sound and record production. In the quest for ever-heavier sounds with great intelligibility (Berger and Fales 2005; Mynett 2012), metal music production has greatly profited from digitalization that allows recording many instruments on separate tracks and mixing multiple layers of guitar (Mynett 2012, 2017; Herbst 2017). In addition, the options for optimizing the recordings by editing, mixing and mastering have vastly expanded (Mynett 2017; Williams 2015). The same applies to live concerts where the dense mix of most metal music genres requires fastidious controlling too. Regarding musical instruments, technological advancements have perhaps most notably occurred in the case of the guitar,[1] arguably the sonic trademark of the metal genre (Walser 1993; Berger and Fales 2005; Herbst 2017). Since the genre's emergence around 1970, the means of controlling the guitar's sound have greatly expanded by improved equalization, adjustable pre-gain stages and presence and resonance controls (Herbst 2016: 36) plus an overall increase of distortion capacities, all of which helped to develop a heavier metal sound (Herbst 2017).

Despite the great relevance or even necessity of technological development for the metal genre, guitar players have generally been distinct from many other instrumentalists regarding their openness towards technological innovation. The synthesizer, for example, was developed to deliberately produce new sounds and playing styles in contrast to the traditional keyboard instruments (Weissberg 2010: 91). Thus, most synthesizer players have embraced innovation, new sounds and means of sound control (Holmes 2002: 151–53). In the history of the electric guitar, however, technological innovation has mostly been faced with scepticism. The first solid body models such as the Telecaster, Stratocaster, Les Paul and Flying V were introduced in the 1950s, followed by the SG in the early 1960s. These guitars are still very popular notwithstanding that more modern ones are on the market (Théberge 1993: 177; Herbst 2016: 297–99). Seymour Duncan and Dimarzio, for instance, created a profitable product line with exact replicas of pickups from the 1950s, 1960s and 1970s. Equally successful are Fender and Gibson with reissues of their former guitar models (Uimonen 2016: 5). A similar development occurred with innovations in amplification technology. The electric guitar was initially played through valve amplifiers like the Fender Bassman not specifically designed for the guitar (Bacon 1996: 14–15). With the rise of the solid body guitars, several manufacturers such as Marshall, Hiwatt, Orange, Vox and Fender in the late 1950s started to produce valve amplifiers for the guitar that shaped the sound of hard rock and heavy metal (Stephens 2015). Extra equalization options and additional resonance and presence controls were introduced in the 1960s and 1970s to improve the options of adjusting the sound (Herbst 2016: 36). These early amplifiers are still popular today, and

1. Other instrument sounds have changed as well. For instance, the bass guitar was increasingly processed with the expansion of digital audio production, and triggering devices not only helped to quantize the drums but also to implement heavily manipulated drum samples (Mynett 2012, 2017).

many modern devices are contemporary derivations with greater gain capabilities through an additional pre-amplifier section (Brosnac 1987; Herbst 2016: 297–305). Little has changed for most models as inventor Jim Marshall declared: 'Since 1962, we've basically made the same amplifier. There's hardly any difference. What we do is about getting the Marshall sound' (Maloof 2004: 74). For the largest part of their careers, bands such as Slayer, Anthrax and Iron Maiden relied on the Marshall JCM800 2203 that emerged in 1975 (Maloof 2004: 209–14). Newer models, the JVM series for instance, are characterized by a greater functionality due to its higher number of channels. Marshall (2017) nevertheless advertises the JVM410H, a model endorsed by Iron Maiden, HammerFall, Megadeth, Children of Bodom, Opeth and Arch Enemy, with classic sounds: 'Combining some of the finest Marshall sounds, the JVM410H has a vast tonal palette, taking you from "Plexi"/JTM45 cleans through JCM800 roar to modern high gain'.

Amplifier technologies more advanced than valve amplification emerged but these were hardly accepted by guitarists for different reasons. As early as 1948, transistor technology was introduced to guitar amplification, yet it had deficiencies in producing distorted sounds (Doyle 1993: 56). The higher voltages of valve amplifiers produced rounder waves, whereas the waves resulting from a transistor design were limited hard because of their low voltages in the solid-state circuit (Brosnac 1987: 8). The drastic limitation of the signal with the transistor technology intensifies uneven-numbered harmonic integers that generally are perceived as harsh, rough, sterile and not very musical (Doyle 1993: 57). Valve amplifiers, in contrast, extend the signal by strengthening even-numbered partials (Bacon 1996: 147) which results in a sound perceived as warmer, dynamic and more pleasant (Berger and Fales 2005: 185). Despite these commonly described differences, an experimental study by Einbrodt (1997: 159) proved that in reality the technological differences are smaller. Lemme (1995: 47) similarly noted the circuit and components to be more relevant than the presence of valves.

To improve control over the sound and to produce effect-laden tones, modular rack systems became popular in the 1980s (Bacon 1996: 25), controlled by MIDI but often still based on valve amplification. In the 1990s, rack systems lost their popularity and many guitarists moved back to traditional combo or separate head and cabinet systems (Bacon 1996: 26–27). What is more, power soaks that have become more common in the 1980s inspired manufacturers since the 2000s to reduce the output of many models thus marking a retro trend with sound ideals of the early valve amplifiers (Herbst 2016: 99–106). This current trend of low wattage valve amplifiers combined with vintage guitars was empirically confirmed, except for extreme metal guitarists; those players tended towards higher wattage and more advanced technology (Herbst 2016: 297–305).

Digitalization found its way into guitar technology in 1989 when Tech 21 released the SansAmp, an analogue valve amplifier emulator that is considered the prototype of guitar modelling technology (Vinnicombe 2012: 119). It took further six years until Roland released the first fully digital guitar and amplifier modelling device, the VG-8. Despite its innovative approach and superior capabilities, the Line 6 POD released two years later became more popular than the VG-8, especially for practising purposes. With its small size, low volumes and its headphone output, it was predestined for casual playing at home. Both the VG-8 and the POD, like many of its successors, are based on a technology that digitizes the input signal and uses a digital signal processor (DSP) to imitate the circuits of analogue amplifiers based on algorithms. This technology is available as an effects unit without speakers (digital amplification modellers) and as regular amplifiers with a speaker (digital modelling amplifiers). The sound design options of most modellers are not restricted to the amplifier (pre-amplifier and power amplifier) but include selectable speakers, microphones and microphone positions.

For different reasons such as perceived sound quality, look, latency in the playing response and lack of definition in a band context or mix (Burns 2016), modelling technology was disdained by many players for a long time. Similar to modelling solutions, digital amplification simulation in a plugin format to be inserted in digital audio workstations emerged in the early 2000s. It was received well for tracking demo performances but rarely considered a serious alternative to recording valve amplifiers.[2] In recent years however, the improved quality of modelling devices and plugin simulations sparked the debate on valve versus modern technology again. Products destined for the semi-professional and professional user, for instance Fractal Audio Axe-FX, Avid Eleven Rack, IK Multimedia's AmpliTube and Native Instrument's Guitar Rig, have become increasingly popular among (metal) guitarists and producers alike (Eichenberger 2015).

2. This scepticism against digital amplifier simulations is still visible today. For example, Chappell (2010: 31) in his book *The Recording Guitarist* briefly mentions modelling and simulation solutions in passing but does not consider them any further when describing recording practices.

In 2011, a new 'profiling' technology was announced with the release of the Kemper Profiling Amplifier that promised not to modulate but to copy the exact sound and playing feel of valve amplifiers (Kemper 2017a). It received much attention among guitarists and music producers because it presented the prospect of combining the valued sounds of rare historical valve amplifier models with the benefits of digital technology such as better durability, flexibility, live practicability and an unlimited range of sounds. Many professional rock and metal guitarists such as Ola Englund (The Haunted, Six Feet Under, Feared), Mitch Harris (Napalm Death), Matt Heafy (Trivium), Wolf Hoffmann (Accept), Greg Mackintosh (Paradise Lost), Olavi Mikkonen and Johan Söderberg (Amon Amarth), Eric Peterson and Alex Skolnick (Testament) and Jeff Loomis (Nevermore, Arch Enemy) have ventured the step towards profiling technology. Several rock and metal music producers famous for their guitar sound, Michael Wagener (Metallica, Alice Cooper, Ozzy Osbourne), Andy Sneap (Megadeth, Machine Head, Testament, Carcass, Killswitch Engage), Sean Beavan (Slayer), Kevin Churko (Five Finger Death Punch) and Tim Palmer (Ozzy Osbourne), embraced this new technology too. Profiling may thus be the first digital technology for the guitar convincing many music professionals in rock and metal music.

Mynett (2013: 18–19) highlighted metal music research from the perspectives of music technology and production being in an 'embryonic phase'. In recent years, few works have emerged analysing the history of metal music productions with a focus on production tools and conventions (Williams 2015; Herbst 2017) whilst others concentrated on production techniques (Herbst 2017; Mynett 2017). From the viewpoint of music technology, many blind spots still exist, especially concerning contemporary practices in metal music performance and production, including economic aspects from a professional perspective. Considering its significance as shown by vivid debates among rock and metal musicians and producers in online communities, it is surprising that the guitar profiling technology has not yet received any academic attention.

The present study pioneers in exploring this technology by testing its capability and by discussing potentials and drawbacks for professional metal music producers. It follows an empirical two-part design to consider both the cultural and the technical aspects. After a brief description of the technology, the article qualitatively investigates the device's public reception in reviews and online discussion boards to condense practice-based experiences and to consider the subjective perspectives. A subsequent acoustic experiment systematically tests the capability of the technology, aiming at detail by addressing previously found criticism and by focusing on relevant parameters such as level of distortion, musical structures and aspects of playing. Hence, it continues the practice in reviews and discussion boards to test the technology with non-standardized listening experiments and simple acoustic tests, yet this study does so with academic tools acknowledged in music information processing and psychology of music. Taking into account the quantity of these tests along with discussions in the public, there seems to be a general interest among metal guitar players and music producers in the quality of profiling technology. This is hardly surprising as music productions, either in a professional studio or self-produced, could do without a huge collection of valve amplifiers for providing a variety of guitar sounds (Wagner 2013). The right guitar sound is crucial for the overall production, and the sound quality is essential for the powerful effect expected within most metal genres (Herbst 2017; Mynett 2017) and thus required for success (Mynett 2013: 61). Hence, if profiling technology produced convincing results, the needs for self-producing bands or professional studios to own highly specialized and expensive valve amplifiers would dwindle, ultimately leading to a democratization of production tools (Jones 1992; Théberge 1997) and to an empowering of aspiring metal bands and producers. Such consequences as well as aesthetic and ethical dimensions will be discussed in accordance with the experimental results.

Regarding the objectivity of this research, it seems necessary to mention that we are a group of guitar players, record producers and musicologists who are motivated by practice-oriented and academic interests. None of us is or ever was affiliated with the Kemper Company, and we by no means aim to promote the profiling technology. Our effort rather is to explore options for professional practices and to initiate the academic discourse on this technology.

The guitar amplifier profiling technology

The guitar profiling technology was invented by Christoph Kemper. It became available with the Kemper Profiling Amplifier in 2011, which until today is still the only profiling device for the guitar. Having developed the Access Virus synthesizers before concentrating on guitar sounds, Kemper was intrigued by the complexity of valve amplifiers and the limitations of modelling technology to produce authentic guitar sounds.

> Modeling […] is bringing the physics of the real world into a virtual world by defining formulas for the real world and letting them calculate on a real-time computer (such as a DSP or a plug-in environment). […] Profiling is an automated approach for reaching a result that is probably too complex and multidimensional to achieve by ear, or by capturing the behavior of individual components in isolation. This is the case for a tube amp. By philosophy, 'modeling' was used as a marketing term by some companies. It says: 'Here is a valid virtual copy of a valuable original'. What I have rarely seen is an A/B comparison between the

> original and the virtual version. Why is that? Profiling […] is a promise to create a virtual version of your original, but with the ability to qualify the results by a fair A/B comparison. You get what you want, and you can check what you have just got.
>
> (Kemper in Collins 2011)

As the company describes on their official website (Kemper 2017a), modelling amplifiers are limited by predefined algorithms unable to cover the individual nuances of valve amplifiers. The profiling process distinguishes between clean and distorted signals. Both sounds require the basic profiling but due to its greater tonal complexity, distorted sounds need a 'refinement'. In the refinement process, guitar playing of approximately twenty seconds allows the profiler to analyse the amplifier's response to authentic playing. The official Kemper Profiling Guide describes the profiling process as follows:

> The Profiler then sends various tones and signals into the reference amp – it will sound like warbles and static at various pitches and intensities, in other words: not too musical! To get technical for a moment: these dynamically changing sounds allow the Profiler to learn about the nonlinear behavior of the tube architecture, and the dimensions of the passive components in the original amp. The Profiler then listens to how the reference amp reproduces these sounds, and analyzes the results. These characteristics are then recreated in the virtual signal flow of the Profiler. Even the characteristics of the speaker cabinet and microphones, including all the frequency buildups and cancellations, are detected and become a part of the Profile.
>
> (2016: 8)

Audio Example 1[3] provides an aural impression of the profiling process. In an interview, Kemper further explained:

> The pulsing white noise modulates the saturation and thus the current of the distorting tube […]. By checking the residual distribution of the noise and the slight changes in the frequency response, a number of circuit parameters can be solved. The 'UFO' sound does roughly the same, but seen – or heard – from a different angle: it is a fast sweeping group of sine waves creating interference signals in the distortion stage. The analysis of the interference results solves another handful of parameters.
>
> (Collins 2011)

The profiling amplifier serves two main purposes, first to provide virtual high-quality copies of renowned amplifier sounds and second to profile and to modify personal guitar sounds. Regarding the first objective, the official website (Kemper 2017a) advertises the stock model to ship 'with over 300 profiles, created in studios around the world, featuring vintage classics, modern high-gain amps, and rare boutique items'. The profiles include much sought-after models by BadCat, Bogner, Diezel, Fender, Marshall, Orange, Mesa Boogie, Soldano, Splawn and VOX. These amplifiers can be combined with different cabinets and speakers. Further options available are selectable microphone sounds by AKG, Neumann, Royer, Sennheiser and Shure. Classic vintage pedals like the Tube Screamer TS808 can be added to the signal chain

3. All audio files are available to download in the digital Appendix located in the Supplementary Data section for this article: https://ingentaconnect.com/content/intellect/mms/2018/00000004/00000003/art00005.

too. To extending these sounds, the official website hosts a community where profiles are shared (Kemper 2017b). What is more, amplifier packages such as the 'Michael Wagener Signature Rig Pack' and the 'Keith Merrow Signature Rig Pack' are offered commercially, but others such as the 'Lars Luettge Signature Rig Pack' are distributed for free. In case that the profiling has been done properly, as can be expected from licensed profiles, Kemper (2017a) promises the copy to be '[s]o close that you won't be able to distinguish [it] from the original' and to be reacting 'to your individual guitar and your playing style, as the original amp would have'.

The second purpose of the device is to virtually copy and optimize personal guitar sounds. The Kemper Company describes this as follows:

> We use proprietary digital technology to analyze the sonic DNA of your amp. As a result, you can go beyond what's possible with the original amp and tweak everything to your liking. Use the gain control and equalizer in a regular fashion to adapt the sound to your guitar. Add power sagging to the distortion and tweak the power of your pick attack without compression. Or exchange the cabinet later on. The Profiler gives you more freedom of choice than any other real or virtual amp available.
>
> (Kemper 2017a)

This function allows turning a vintage amplifier with limited distortion capacities into a high-gain device with the original sound characteristics. Additionally, the sound can be shaped further with a studio equalizer (Collins 2011). Another feature unavailable with any 'real' amplifier is the function to adjust the transient characteristics by altering the picking sound and to shape the overall resolution important for the perceptibility of individual notes in a chord. The latest operating system (5.1.1) supports a layering function that allows merging sounds, produced by different amplifier sounds, cabinets, speakers and microphone positions, into a new sound not possible with just one guitar and amplifier. The device can thus produce sounds both heavy and intelligible that are only possible to create with traditional gear in elaborate music productions (Herbst 2017; Mynett 2017).

Apart from the guitar player, the company considers music production as well. Regarding studio work, the official website states:

> The Profiler revolutionizes the typical workflow of a recording session. By taking profiles of a mic'ed up guitar rig, guitarists for the first time, can freely move in between projects and go back at any time, for overdubs and alternative takes. Rent a professional studio for one or two days to create the best profiles of your amps. Record in your project studio later on with the sound and feel you had earlier on – without time or money pressure. Think reamping […] Wouldn't it be great to reamp tracks with the exact same sound and response later when you're already working on the final mix? Without rebuilding the entire recording setup just because the producer want to continue working on a different song?
>
> (Kemper 2017a)

The list of endorsed music producers includes many renowned names in the metal genre such as Michael Wagener, Andy Sneap, Sean Beavan, Kevin Churko and Tim Palmer.

Public reception

Before putting the Kemper Profiling Amplifier to the test, reviews and practical experiences from guitar players and music producers were analysed to determine strengths and weaknesses as criteria derived from the musical practice. Reviews in music production and guitar player magazines and discussions in respective online boards were analysed to explore the range of experiences. The sample consists of 24 reviews and 35 threads in the forums Gearslutz.com, Homerecording.com, KVRAudio.com, SoundonSound.com, Studio-Central.com, Ultimatemetal.com and Kemper-Amps.com. Most threads comprise several pages, maximum 56 pages with 1119 posts in the Ultimate Metal board. The forums were chosen because they represent a mixture of discussions among guitar players and music producers. Categories have been extracted with a qualitative content analysis approach (Cresswell 2003: 189–200).

Reviews

In all reviews, the tradition-consciousness and tendency to favour analogue vintage amplifiers were apparent (Aurigemma 2015). Most reviews had negative undertones or explicit expressions of scepticism notwithstanding the interest in the potential of profiling technology: ‘Our culture is bound up in ritual, superstition and myth – and we like it that way. We know great tone and it sure as hell doesn’t come from ones and zeroes’ (Vinnicombe 2012: 119). The ambivalent notion was also apparent regarding the prospect of greater convenience and availability of historical amplifiers as some guitarists worried that their expensive collection of historical amplifiers would become obsolete. Others claimed not to change technology for nostalgic reasons (McKenzie 2017). Despite these ideological reservations, all reviews rated the sound quality as very good. Complying with the two primary uses of profiling, the reviews tested both the stock amplifier models and the quality of self-made profiles. About the first application, Anderton (2013) resumed:

> The KPA sounds really good out of the box. The sounds are very, very close to ‘real’ amps, and are satisfying in their fullness. The KPA has gotten a huge buzz, and even won multiple awards from MIPA (Music Industry Press Awards). But play with it for a while, and you’ll find that the buzz is justified – the KPA doesn’t just do its job, it breaks new ground.

Regarding profiling own amplifiers, Greeves (2012) highlighted the ‘impressive sense of depth, detail and realism to the amp sounds on offer, both in terms of tone and the way they respond to playing dynamics’, and Davodowich (2015) praised the device being able to ‘capture those small nuances to such a degree that playing our profiles truly feels like we are playing through the actual amps. We didn’t have to try and squeeze the feel and tone from our fingers – it was present and as accurate as the real amplifier’. Especially the nuances, as for instance the ways valves react to string attack, were evaluated positively (Davodowich 2015).

In guitar player and producing magazines alike, the capabilities of the profiling amplifier for recording were stressed. Greeves (2012) noted that

> it’s the ability to create new profiles that’s most exciting […]. Even if it means hiring a studio and spending a whole day making profiles, the prospect of having all your favourite settings on your amps […], as

> they would sound properly miked up, sitting in box on your desk and available at the flick of a switch, is something to really get home-studio owners thinking.

Therefore, the technology may be setting trends of booking studios for profiling sessions similar to recording drums at a professional studio in the context of project studio productions. In addition, producers could benefit from profiling the band's amplifiers, building their own collection of sounds useful for future projects (Beech 2012). With the means to merge and layer sounds, the device was considered 'an entire computer dedicated as a production suite for guitars' (Beech 2012). Hence, Vinnicombe (2012: 122) concluded 'that the Kemper is a product that is best suited to serious musicians. […] if you're the type of guitarist who records regularly, or a producer who wants 24/7 access to a personal library of refined and tested guitar sounds wherever you happen to be on the planet at any given time, the Kemper Profiling Amp is the product of the decade so far'. In total, no critical statements were present in the reviews. However, a biased review could not be ruled out since hidden intentions in music journalism are possible.

Online discussion boards

The members of the online boards discussed the profiling technology more critically. Still, many stressed the good sound quality and functionality of the device.

> The Kemper is current king of the crop. It sounds and plays like the real thing to the extent that these days most people can't tell which is which side by side, let alone in isolation […] in the same situation. i.e. either mic'd up in isolation or used as a pre-amp for a real guitar cab. It can sound exactly like your own amps, with your own preferred setup.[4]

The quality of the profiled copies was widely acknowledged and for some users it made digital technology an alternative to analogue valve amplifiers: 'I can truly say, with guitar being my instrument that it is the best gear purchase of my 35 years of spending money on this stuff. It was also the first sign to me that digital had turned the corner'.[5] Further statements supported the arguments in the magazine reviews: large collection of different sounds, replicating sounds later in the mixing phase or between recording sessions, taking album sounds onstage and modifying historical models. Especially for home-producing artists and producers working with semi-professional bands, the benefits were highlighted.

> If you have artists coming in to record, having amps there is a good selling point IF you are dealing with lower level bands who don't own their own amps. […] The Kemper is invaluable here in that I have artists come and bring their amps, I mic them up and profile them (so I can use them in the future anytime I want or if they need to punch in) and I send them home with the KPA to record at their leisure at home with their own miked up amp profiles.[6]

The line between home recording and professional production thus becomes blurry. Yet, there also was criticism on the sound quality. Some

4. https://www.gearslutz.com/board/so-many-guitars-so-little-time/1124029-amp-sim-people-hate-amp-sims-2.html. Accessed 18 June 2018.
5. https://www.gearslutz.com/board/so-many-guitars-so-little-time/1115828-kemper-worth-money.html. Accessed 18 June 2018.
6. https://www.gearslutz.com/board/so-many-guitars-so-little-time/905072-kemper-real-amps.html. Accessed 18 June 2018.

criticized the clean sounds, especially regarding the articulation and dynamics. Most criticism, however, concerned the distorted sound and differences in particular frequency areas (Herbst 2017). The upper mid frequencies and the presence were claimed to be harsher than with the original amplifier, giving the sound some artificial quality. The opinions varied as others perceived the air area above 10kHz to be thinned out. The greatest differences were reported in the bass response, one user describing it: 'My main issue is that the low-end doesn't sound right at all. The Kemper sounds high-passed and palm mutes don't translate well. […] I can basically hear the mids getting louder but the low-end seems to stay put'.[7] Due to this common problem, users compared auditory impressions and analysed the signals in digital audio workstations.[8] Particularly the 125-Hz area necessary for the characteristic 'oomph' in metal music (Hamidovic 2015: 63) was claimed to be lacking. Concerning all reported problems, the quality of the refinement process was regarded as crucial, and some amplifier models were found to be more difficult to profile than others were.

7. www.ultimatemetal.com/forum/threads/kemper-profiling-amp.832189/page-49. Accessed 18 June 2018.
8. www.ultimatemetal.com/forum/threads/kemper-profiling-amp.832189/page-32. Accessed 18 June 2018.

Acoustic experiment

Data

The quality of the profiling technology was tested with an experimental design. A PRS SC250 was chosen as the reference guitar because it is a mixture of a Fender- and a Gibson-type guitar with a scale length of 25". Sixteen different valve amplifiers (see Table 7 in the Appendix) were tested. All amplifiers were recorded at 115dB in a professional recording studio with a Shure SM57 dynamic microphone in front of a Marshall 1960AV cabinet with Celestion Vintage 30 speakers. Fourteen stimuli were recorded in Logic Pro X with a MOTU 424 PCI audio card. These stimuli later were re-amped using a Palmer Daccapo box. White noise and needle pulse served to test envelope and frequency response. The chords G, C, D, Em, Am and Dm represented common chords with the root notes on different strings. A high E5 (660 Hz) with vibrato played on the 12th fret on the sixth string served to capture a melody note. For testing whether the gain reduction of valve amplifiers was replicated authentically with the guitar's volume control, a D power chord in open position with a drop D tuning was recorded with a fade out. Additionally, palm-muted notes B1 (62Hz) and respective power chords with a lower tuning were recorded to verify the critique of lacking bass frequencies. With these stimuli, elementary aspects of sound and playing feel could be captured. All recordings were approximately 20seconds long as to include the whole envelope from the initial attack to the final decay. To further test the quality of profiling, three different sounds (clean, overdriven and distorted) were created with each amplifier. All equalization settings were neutral; the gain and output levels were adjusted by ear and controlled with a decibel meter. For the distorted sound, a Fulltone Obsessive Compulsive Drive (OCD) overdrive pedal was added with tone and level on 12 and drive on 3 o'clock. A small number of amplifiers were incapable of producing clean sounds at 115dB in which cases the output was reduced. All recordings were normalized to –0.1dBFS in the audio export to make up for these peak volume differences. The final data consisted of 1344 recordings produced with the Kemper Operating System 5.1.1.

Acoustic feature extraction and qualitative analysis

Modern music information retrieval technology allows measuring acoustic and psychoacoustic characteristics of sounds that can be evaluated quantitatively. By computationally extracting features that describe details of the spectral as well as the temporal composition of a signal, sounds can be compared objectively. The data of this study was created with an audio-based feature extraction using the MIR (Lartillot and Toiviainen 2007), TSM (Driedger and Müller 2014) and Loudness (Genesis 2009) toolboxes in a Matlab runtime environment. In the data extraction processes, signals were (in most cases) analysed with a short-time Fourier transform (STFT) using half overlapping windows with a length of 0.05seconds. Consequently, measures describing the spectral shape of a sound (e.g. the central areas of the spectrum) and its temporal evolvement could be obtained. In total, 71 signal descriptors were used (see Table 8 in the Appendix) to test loudness, spectral composition, timbre, envelope, harmonic energy and percussiveness.[9] Descriptors were chosen that are commonly used in acoustic signal processing and that have been empirically validated in psychology of music, as well as some features that were specifically designed to capture certain characteristics relevant to this study. Some of the descriptors had standardized units such as dB or Hz (Table 8), others had numeric values resulting from algorithmic calculations standardized in music informatics. While descriptors with units had a semantic meaning, those without units were still valuable for comparing sounds. In total, 95,424 test values were extracted.

In addition to the statistical analysis, qualitative cases were analysed with the spectrogram and waveform functions of the Sonic Visualiser 3.0.2 (Cook and Leech-Wilkinson 2009) to explore playing-related aspects in detail. Spectrograms visualize the number and ratio of harmonic and inharmonic partials, their relative intensities and the temporal development that all contribute to the perceived timbre of complex sounds (McAdams et al. 2004: 167), providing a more holistic picture than single acoustic features do.

9. A detailed list of the signal descriptors, their explanation and respective references are available to download in the digital Appendix located in the Supplementary Data section for this article: https://ingentaconnect.com/content/intellect/mms/2018/00000004/00000003/art00005.

Statistical analysis

The statistical analysis was two-fold to investigate the authenticity of the profiles from different angles. For analysing timbral differences between original and profile, univariate analyses of variance (ANOVA) with effect size partial eta square (η^2) were calculated for all signal descriptors. Additionally, the number of significant differences when performing multiple paired sample t-tests with Bonferroni correction was measured with unweighted and weighted values. For the latter, all Gammatone parameters (1–10) were counted with factor 0.1. The mel-frequency cepstral coefficients (MFCC) (1–13) values were counted with factor 0.2 due to their importance for determining timbres. All other descriptors had the factor 1. If not explicitly stated, the white noise and needle pulse test tones were not included into the statistical analyses since they did not represent authentic guitar tones.

Quantitative results

At first, the total sample was tested for acoustic and psychoacoustic differences between original amplifiers and their profiles. Table 1 shows the ten descriptors with the greatest effect.

Descriptor	**MFCC 9**	**MFCC 4**	**RMS Gammatone 1**	**MFCC 10**	**MFCC 13**
Effect	0.237***	0.096***	0.088***	0.050***	0.043***
Descriptor	MFCC 8	First Attack Time Gammatone 10	Release Time Gammatone 8	Spectral Flatness	MFCC 12
Effect	0.037***	0.024***	0.024***	0.023***	0.022***

Note: ***$p < 0.001$; $N = 1152$.

Table 1: Most significant descriptors in the ANOVA test between original and profile for the total sample.

Descriptor	**MFCC 9**	**Release time Gammatone 8**	**MFCC 10**	**Maximum RMS value**	**RMS Gammatone 5**
Effect	0.231***	0.107***	0.102***	0.100***	0.076***
Descriptor	MFCC 4	Loudness (Sone)	MFCC 8	RMS	Percussive Energy
Effect	0.074***	0.071***	0.069***	0.060***	0.050***

Note: ***$p < 0.001$; $N = 384$.

Table 2: Most significant descriptors in the ANOVA test between original and profile for clean sounds.

10. RMS means 'root mean square' and denotes the average loudness of a signal.

The biggest differences occurred in the MFCC that capture timbral properties by parametrising the rough shape of the spectral envelope (Müller 2015: 177) with closer approximation to the non-linear human hearing than the linear frequency scale does (Lartillot 2014: 129). This result indicates audible deviations concerning the timbre of the sounds. The Gammatone function is a linear filter described by an impulse response that allows analysing features related to the spectral composition as well as the temporal envelope by using ten filter bands arranged from low to high. The results show that the loudness in the lowest region differed to a medium to large effect with the profile being louder. Furthermore, the envelope was slightly different with greater values of the original amplifiers in the higher filter bands. Spectral flatness, describing the distribution of power in all spectral bands, was greater in the profiles, meaning that they contained more non-periodic noise (Dubnov 2004). Besides these differences, interaction effects between profiles, sounds, structures and amplifier models were rare and only had weak to medium effects. Profiles and sounds interacted regarding RMS[10] Gammatone 1 (η^2=0.091; p<0.001) whilst profiles and amplifier models did so concerning MFCC 4 (η^2=0.057; p<0.001).

The *clean sounds* differed from the total sample in some regards (Table 2). Apart from differences in some MFCCs, the original amplifiers had higher values of maximum RMS value, Loudness (Sone) and RMS which indicates that the profiles are quieter.

The *overdriven sounds* (Table 3) mostly differed in the MFCCs and in loudness-related aspects. Especially the RMS energy in the first Gammatone band differed with a very strong effect; the profiles had higher values, complying with also slightly higher Maximum RMS Values of the Kemper. In contrast, the First Attack Leap, defined as the amplitude difference between the beginning and the end of the attack phase, was higher for the original amplifiers, indicating a slightly greater dynamic response of the real device.

The first Gammatone band of the *distorted sounds* (Table 4) showed great variance regarding RMS volumes with the profiles having greater intensities.

Descriptor	MFCC 9	RMS Gammatone 1	MFCC 4	MFCC 13	MFCC 12
Effect	0.192***	0.191***	0.074***	0.063***	0.037***
Descriptor	First Attack Time Gammatone 10	First Attack Leap	MFCC 8	MFCC 10	Maximum RMS Value
Effect	0.033***	0.031***	0.024**	0.023**	0.019**

Note: ***$p < 0.001$, **$p<0.01$; $N = 384$.

Table 3: Most significant descriptors in the ANOVA test between original and profile for overdriven sounds.

Descriptor	MFCC 9	MFCC 13	MFCC 4	RMS Gammatone 1	Spectral flatness
Effect	0.322***	0.268***	0.244***	0.198***	0.111***
Descriptor	MFCC 2	Spectral Kurtosis	MFCC 3	RMS Gammatone 9	MFCC 10
Effect	0.090***	0.084***	0.080***	0.044***	0.047***

Note: ***$p < 0.001$; $N = 384$.

Table 4: Most significant descriptors in the ANOVA test between original and profile for distorted sounds.

The profiles strongly differed from the originals in their spectral flatness and kurtosis; the profiles were noisier in terms of non-periodic content. Furthermore, the effects in the MFCC bands were much stronger with the distorted than with the clean and overdriven sounds, indicating greater differences between the originals and profiles with distortion.

Estimating the differences with regard to stimuli and sounds further, Table 5 demonstrates that real guitar tones were reproduced by the profiles much more authentically than test tones were. Moreover, the most authentic profiles could be produced with overdriven sounds. Clean and distorted sounds deviated from the original more.

The analysis of the online boards suggested that the quality of the profiles considerably depends on the particular amplifier model. This proved to be true as Table 6 demonstrates. Considering the effect sizes and number of significant differences, the Earforce profile hardly differed from the original, whereas the Mesa Boogie Triaxis with 2:20 power amplifier deviated most. This complies with the listening impression, for instance of an overdriven Em chord (Audio Examples 2a, 2b, 3a, 3b). However, based on a sample size of 16 amplifiers, no systematic differences in the quality of the profiles could be concluded concerning amplifiers' characteristics, types of valves or output power. Rather, the sound settings and especially the gain level seemed to be crucial for the quality. The Kemper Profiling Guide (2016: 16–17) highlights the importance of playing for the refinement but since the same performance was used, this variable is ruled out.

Summing up, the quality of the profiles was generally very good with a low average of 6 out of 71 (8 per cent) unweighted and 1.7 out of 32.6 (5 per cent) weighted descriptors significantly deviating from the original. The overdriven sounds were profiled most authentically whilst clean and distorted sounds differed more from the original. However, since the effect sizes of some parameters were very strong, further qualitative and perceptual confirmation was required to reach a final conclusion on the profiles' quality.

	All guitars	Clean guitars	Overdriven guitars	Distorted guitars	White noise	Needle pulse
Cumulated η^2	0.783	1.603	0.895	1.923	4.504	6.798
Mean η^2	0.011	0.023	0.013	0.027	0.063	0.096
Unweighted significances	25	31	16	26	23	43
Weighted significances	6.2	11.8	7.6	7.8	8.4	19.5

Note: 71 unweighted significances and 32.6 weighted significances were the maximum.

Table 5: Differences between original and profile for different stimuli.

	Bogner	Earforce	Engl	Fender Super	Fender Twin	Fryette	Laney	Marshall 1987
Cumulated η^2	0.858	0.502	1.117	1.174	0.873	1.544	1.521	0.902
Mean η^2	0.012	0.007	0.016	0.017	0.012	0.022	0.021	0.013
Unweighted significances	4	2	5	4	3	11	6	2
Weighted significances	0.7	0.4	0.9	1.4	0.5	3.5	1.9	0.3
	Marshall JCM	Triaxis 2:20	Triaxis 5150	Orange	Peavey	Real guitars	Splawn	Vox
Cumulated η^2	1.346	3.064	1.277	1.450	1.397	1.905	0,.954	0.797
Mean η^2	0.019	0.043	0.018	0.020	0.020	0.027	0.013	0.011
Unweighted significances	7	14	8	6	8	10	5	4
Weighted significances	2.7	4.7	2.1	1.9	2.2	1.5	0.8	1.5

Note: N = 72 for every amplifier; 71 unweighted significances and 32.6 weighted significances were the maximum.

Table 6: Differences between original and profile for amplifier models.

Qualitative analysis

To do justice to the musical practice, playing-related issues such as melody playing, controlling the gain with the guitar's volume control and the palm muting of low power chords were analysed qualitatively. The sample was limited to overdriven sounds because they are more complex to profile than clean sounds and because profiling, according to the official Profiling Guide (2016: 8–9), is known to have problems with some boosting devices.

Based on the listening impression, the melody note E5 sounded very similar in both recordings in the case of the Bogner Goldfinger (Audio Examples 4a, 4b). In the attack phase, the original had a more distinct plectrum attack due to its louder upper partials. However, the signals did not noticeably differ in the phases of sustain and decay. Figure 1 complied with the listening perception. The waveforms demonstrated a longer attack phase in the Bogner recording that correlated with the spectrogram too. Although the partials

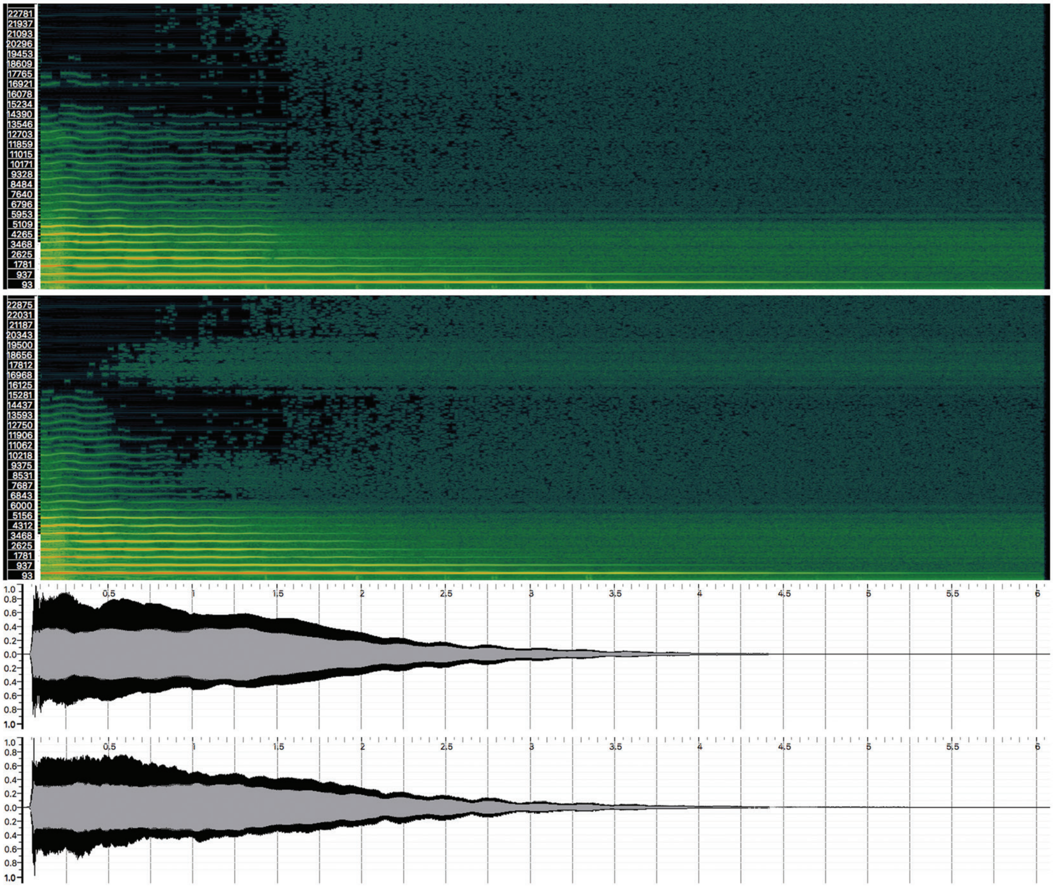

Figure 1: Spectrograms of a E5 (660Hz) note with vibrato played with an overdriven Bogner Goldfinger amplifier; top: original; bottom: profile; 1024 window.

in both recordings reached the twenty-third integer (approx. 14.5kHz), the upper partials over the primary frequency range of the speaker above 5kHz (Celestion 2017) decayed much faster in the profiled sound. In the decay phase, both recordings did not differ significantly. Apart from these variations, the spectrograms demonstrated an additional noise band between 16 and 20kHz in the profiled sound not present in the original.[11] However, no significant differences could be perceived even when listening with a high-pass filter set at 15kHz.

In contrast to the small differences of the melody note, the profiled D power chord, faded out with the volume control, was perceptually inseparable from the original Marshall 1987X (Audio Examples 5a, 5b). Figure 2 demonstrates almost identical waveforms and only minor deviations in the spectrograms. Even the small cuts in the frequency range at 6 and 6.5kHz were replicated authentically. Only the overtones decayed faster in the profiled sound yet barely audibly.

The reproduction of low notes, especially when played with palm muting, was criticized in the online boards. Figure 3 illustrates a palm-muted power chord played with a Peavey 5150. Both waveforms and spectrograms showed

11. These different noise bands in the higher frequency register may contribute to the significant deviations of the higher MFCCs.

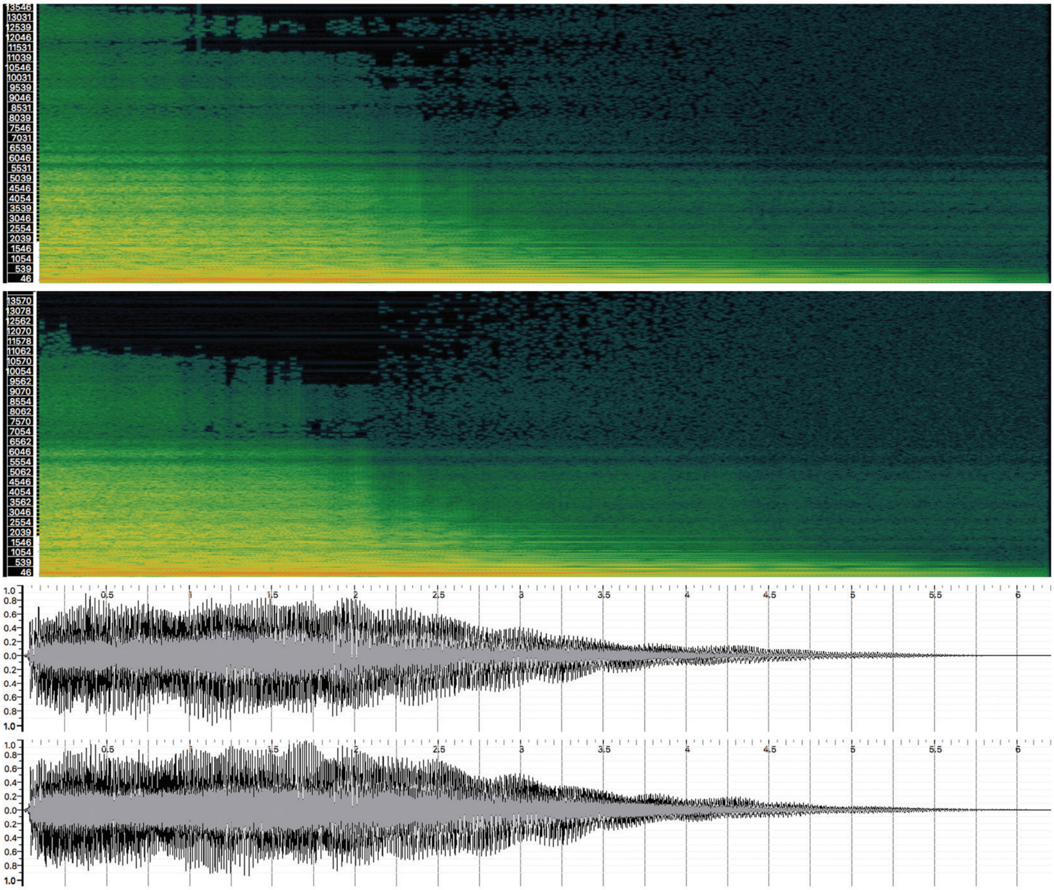

Figure 2: Spectrograms of D power chord in drop D tuning played with an overdriven Marshall 1987X amplifier; top: original; bottom: profile; 2048 window.

great resemblance except for the different position of a short vertical noise band throughout the whole frequency spectrum that however was inaudible. Per listening impression, the timbre of both recordings was identical except for an added reverb in the profile giving it a slightly artificial metallic tone (Audio Examples 6a, 6b). Comparing different amplifiers of the sample, the profiles of high-gain 'metal amplifiers' (Peavey 5150, Engl Powerball, Fryette Sig:X) had this reverberated sound. It is likely that the profiling algorithm interpreted the sound having an effect. If noticed during the re-amping process, this effects section could have been switched off. Other profiles as for instance the Splawn Quick Rod were authentic (Audio Examples 7a, 7b). There were also many cases of overdriven sounds being interpreted with reverb when the distorted sound was not. Neither the listening impression nor the qualitative acoustic analysis could confirm the critique of lacking intensity in the bass frequencies.

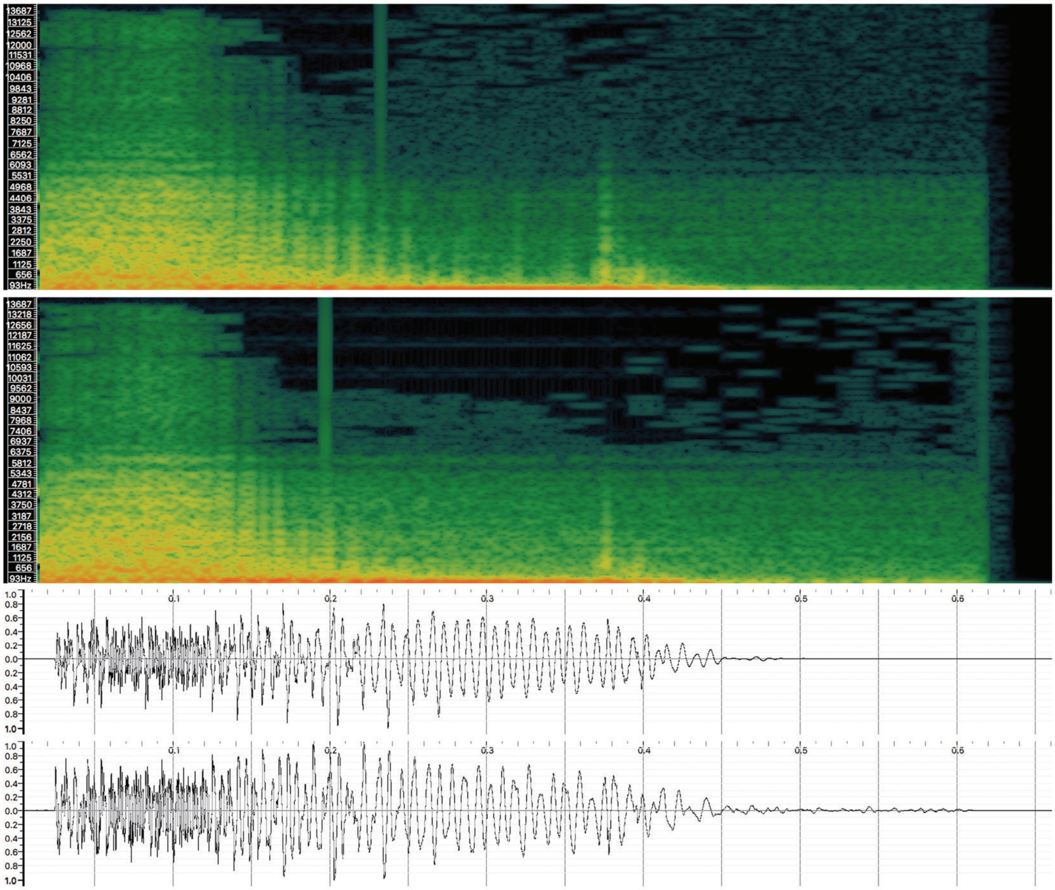

Figure 3: Spectrograms of a B1 (62Hz) palm-muted power chord played with an overdriven Peavey 5150 amplifier; top: original; bottom: profile; 2048 window.

Subjective experience of the experiment

In the recording and subsequent listening sessions, we were surprised by most profiles matching the original so closely that in a blind test, they could not be distinguished. The sound and the dynamic response were authentic. Another observation concerned the interpretation of the original amplifier's sound. The distorted sounds produced with an additional boosting pedal sometimes were resonating whilst lacking intelligibility in the presence range. The profiles however were quite different from the original but more apt for real musical use since the problematic features were corrected, making the sound more transparent as for instance in the case of the Fender Super-Sonic (Audio Examples 8a, 8b).

Even if the sound quality in most cases was very good, there also were some problems. As profiling required high volumes, a six-watt amplifier (VHT Special 6 Ultra) had to be excluded from the sample. This limits the use for bedroom producers. Another observation concerned differences in the sustain phase where the sounds of some profiles decayed earlier than they did with the original amplifier. Clean sounds posed another problem because at the break-up point, they often were interpreted as overdriven sounds, which led to a more distorted profiled sound, for instance with the Laney GH50L (Audio Examples 9a, 9b). Moreover, the distorted sounds partly lacked quality because boosting devices were not always profiled adequately. Therefore, differentiating sounds with several gain stages seems to be one of the few proven weaknesses of the profiling technology thus far.

Limitations of the experiment

The experimental design is subject to certain limitations. According to the nature of statistical analyses, no case-based A/B comparisons between original and profile were possible. Rather, systematic deviations were found. The acoustic descriptors, even though being validated in music psychology, were another issue since the quantitative results did not allow predicting exactly how listeners would have perceived the profiles. Listening tests with A/B comparisons and with profiles played in a musical context would thus be a valuable extension to the acoustic experiment. The playing feel was another aspect not possible to be explored in detail. Although qualitative analyses and the studio experience point to an authentic playing feel, players need to confirm this. Finally, the findings suggest that profiled guitar sounds are suitable for band performances and music productions; this assumption needs to be verified in authentic contexts too.

Discussion

This article explored the guitar amplifier profiling technology by looking at the cultural and technological dimensions. As the qualitative findings have shown, many guitar players and producers were sceptical about digital amplification technology. This complies with successful metal music producers known for their high-quality guitar sound. For example, Andy Sneap in an online video explained:

> I've always been a bit dubious about things like these profiling amps cause you don't want it to be true, you don't want it to work, you don't want it to be able put your sound into a box. You know, if you can bottle it and sell it. […] We could not believe what this thing did, how accurate it was. When we were profiling amps and switching between the profile and the actual amp, there were times, most of the times, we couldn't tell which one we were listening to. You know, me and Wolf [Hoffmann; Accept] are the most critical people you will find. We both got masses and masses of amps and spent thousands and thousands of pounds on equipment. And we'd be the last people to want to believe this but, to say within two, three hours of trying the Kemper, we were convinced about it. I don't want it to work but it does work.
>
> (Sneap 2012: 3:10–4:30)

This negative attitude can be traced back to the history of the instrument that is characterized by a nostalgic and tradition-conscious mind of many of its players. Even if metal guitar players according to a recent study (Herbst 2016: 297–305) show more openness towards newer technologies than guitarists of other genres do, the online boards and Sneap's statement still indicate that many players and producers in the metal music scene oppose digital guitar technology. Although issues such as role models, visual aesthetics and conventions likely play a role, tonal shortcomings of previous digital technology have been stressed as reason for the common refusal of transistor and modelling amplification. However, as Sneap admits, complying with several statements in reviews and discussion boards, the profiling technology has reached a new level of quality in guitar amplification. This was confirmed in the acoustic experiment of this study. The quality of the profiles was very good overall. Compared to transistor technology and digital simulation often deviating from characteristics of valve amplifiers by a less authentic overtone spectrum and a reduced presence range (Herbst 2016: 134–43), the profiles virtually copied the sonic fingerprint of the original as claimed by Kemper (2017a). Significant deficiencies in the bass response could not be confirmed. In fact, the loudness in the first Gammatone band was significantly higher in the profiles, indicating a powerful low-end. Such minor changes to the original sound even seem to be valued in production practice as Sneap (2014: 13:00) in a more recent video declared 'you can sometimes even beat your tone with the Kemper'. Other deviations such as the profiles' lower volumes do not affect the sound, and this can be compensated by the master volume control in any case.

A benefit of this technology concerns the transition of the produced work to the live stage. As Bennett (1983: 231) noted, '[p]erformers struggled against the disparity between their recorded sound and their live sound throughout the 1950s and 1960s, and slowly their frustrations were turned into a market by musical instrument manufacturers'. In modern rock and metal music, the demand to replicate studio sounds onstage is a challenge for many bands, particularly when touring overseas. With profiling technology, the final sound of various guitar tracks created with elaborate studio processing can easily be transferred to the live rig. It thus allows the guitar player to achieve a very processed live sound, similar to the triggering of the drums that became widely available in the early 1990s. Furthermore, many different guitar sounds can be used in one song for a more elaborate texture as a major quality criterion of most metal music genres (Mynett 2013: 61; Herbst 2017).

Regarding the production process, Wagener (2013: 7:00) points to the producer's need to 'find everybody's tone. That's why I have all those different amps and all that in the studio'. The results demonstrate that profiling technology could reduce the need for a huge collection of amplifiers in the studio without sacrificing quality. Since the profiles are publicly shared and the Kemper Company regularly offers free rigs, digitalization now could be beneficial for metal guitar players the same way it has been the case for keyboarders (Théberge 1997) and for producers because of the decreased costs and extended functionality of respective equipment (Jones 1992; Leyshon 2009). As Martin (2014: 262–63) showed, competing over technical equipment is not popular among many professionals. Guitar profiling technology could diminish the need for owning an extensive collection of high-quality amplifiers. However, this may come at the cost of less individuality if everybody had access to the rarest or most expensive of amplifier models. Nonetheless, as Théberge (2001: 12) noted in the context of home and project studios, the 'sound quality of home equipment has improved to the point where it can often rival that found in commercial studios'. This is why profiling technology takes another step in favour of smaller enterprises and self-producing bands thus shifting the 'dominant networks of power' (Théberge 2004: 773). Just like the computer and the digital audio workstation as the primary medium of record production has granted amateurs access to music production in the 1990s (Martin 2014: 112), digitalization of convincing quality in guitar technology might increase the quality of amateur and semi-professional metal music productions and live sounds.

From the viewpoint of music professionals, this development is more ambivalent. The possibility to store different guitar sounds on a USB stick can liberate producers from studio facilities, supporting to produce bands in different places without having to transport guitar amplifiers. However, the availability of high-quality guitar sounds, as a quality criterion and selling point in metal music (Mynett 2013: 61), for amateur and semi-professional bands and producers may undermine the professional character of a commercial studio. On the plus side, the creative work in the original sense of the producer's role (Kealey 1982: 103–04) would be valued more as there was no need to compete with equipment (Martin 2014: 262–63). However, technical service jobs such as re-amping, currently making up a considerable income source for many professional studios, will increasingly become obsolete.[12]

In the light of such prospects, Sneap (2012: 5:40) predicts profiling technology to 'move recording forward the same way as Pro Tools has'[13] and Wagener (2013: 6:40) concludes it to be 'the biggest innovation for recording at least for the last fifteen years'. But as Wagener (2013: 26:40) also stresses, the device does not replace real amplifiers but extends the tonal palette with the possibility of creating new sounds or of manipulating them for musical purposes.[14] For example, shaping the transient design of guitars in a rock and metal music production to increase the attack and intelligibility (Mynett 2012) is limited by production tools such as equalizers, compressors, envelopers and exciters. With the profiling technology's options of sound control, spectral and temporal aspects of sound can be changed effectively in all phases of the recording and mixing. If not having to decide on the sound while recording, this might retain the creative flow and furthermore could allow modifying the sound aesthetics at a later stage fundamentally. Likewise, with the transpose function the key of a song does not have to be fixed at the recording stage but can be adjusted later depending on the abilities of the singer under studio conditions. Moreover, the possibility to distort classic valve amplifiers to greater levels extends the tonal range of modern high-gain devices (Payne 2012: 1:50). With the guitar steering increasingly towards the digital domain due to this newly established high quality, guitar sounds may change more radically than they have in the last two decades (Herbst 2017) – and along with this also the sound of the metal genre.

Leaving aside questions of aesthetics and ethics, another possible area of application could be to transfer profiling technology, or a derivation of this technology, to the vocal voice as an alternative to the Yamaha Vocaloid voice

12. Another consequence of profiling technology is that some boutique amplifier manufacturers do not sell their products in online music stores anymore to prevent people sending the amplifier back after having profiled the sounds.

13. Pro Tools changed metal music production in the 1990s drastically. Renowned metal music producers like Colin Richardson and Andy Sneap embraced the new possibilities, which helped them achieve the intended sound aesthetics of extreme metal bands such as Carcass (Martinelli 2006; Taylor 2011).

14. In the long run, however, guitarists, producers and listeners may grow accustomed to this processed sound, which may reduce their interest in the original valve amplifiers.

synthesizer that currently is not yet capable of copying real vocal sounds as closely as the profiling technology could, if it were possible to analyse the non-linearities and individual formants of vocal voices. Such a transfer, which would expand the producer's power, comes at the risk of undermining the art of singing. In this respect, another potential step might be to develop vocal technologies such as Auto-Tune and Melodyne further. The electric guitar and the vocal voice still are the instruments in popular music production that cannot be created virtually with a convincing sound quality. With profiling technology however, producers in the not too distant future may be able to create whole songs and albums without any real musicians, just as it has occurred with the vocals in some EDM genres.[15] Alternatively, just as drum computers have been used in metal music productions to simulate double kick drum playing faster than any human drummer could play, guitar riffs and solos could virtually be designed beyond the playing capabilities of any real guitarist. Profiling technology may thus have the potential to change metal music production drastically in the future.

15. Shapiro (2017) even argues for the existence of a 'Vocaloid genre'.

Conclusion

Metal music research from the viewpoint of music technology and production has been claimed to be in an 'embryonic phase' (Mynett 2013: 18–19). Whilst some progress has been made (Mynett 2012, 2013, 2017; Williams 2015; Herbst 2017), many technological dimensions with their aesthetic, ethical and economic consequences are still not explored. What is more, research on technological development has tended to be retrospective (Berger and Fales 2005; Brend 2012; Williams 2015; Herbst 2017). The present study, in contrast, explored the most current guitar technology and discussed possible future application. Many metal guitarists and producers have already embraced profiling technology and its potential for their live and studio sounds. Nevertheless, musicians have been the ones mainly debating about the technology; the general audience does not seem to care much about this invention or have not noticed it yet. The future will show how the potential of profiling technology and its derivates will be used in music production and how notable it will change the music. If the guitar is programmed or singers are replaced by a virtual copy, this could change metal music greatly, giving rise to aesthetic and ethical questions from a general audience.

ACKNOWLEDGEMENTS

We would like to thank Eric Gressel and Benjamin Brümmer for supporting the production of the audio samples of this study.

Appendix

	Amplifier	Output	Power amplifier valves	Character
1	Bogner Goldfinger 90	45	EL34	United Kingdom
2	Earforce 4500 (Marshall modification)	50	EL34	United Kingdom
3	Engl Powerball E645 MK I	100	6L6	United States
4	Fender Super-Sonic	22	6V6	United States
5	Fender The Twin (Red Knob)	100	6L6	United States
6	Fryette Sig:X	40	KT88	United States
7	Laney GH 50L MK II	50	EL34	United Kingdom
8	Marshall 1987X	50	EL34	United Kingdom
9	Marshall JCM2000 TSL	100	EL34	United Kingdom
10	Mesa Boogie Triaxis Vintage Mesa Boogie MK I with 2:20 power amplifier	20	EL84	United States
11	Mesa Boogie Triaxis MK II with Peavey 5150 power amplifier	120	6L6	United States
12	Orange Dual Terror	30	EL84	United Kingdom
13	Peavey 5150 MK I	120	6L6	United States
14	Real Guitars Eddie MK II	50	6P1P-EV	United States
15	Splawn Quick Rod	50	EL34	United Kingdom
16	Vox AC15	15	EL84	United Kingdom

Note: All amplifiers have 12AX7 pre-amplifier tubes except for the real guitar, which has 6N2P.

Table 7: Overview of the amplifiers and their characteristics.

Group	Descriptors
Loudness/intensity	Loudness (Sone), Maximum RMS Position (frame index), Maximum RMS Value, RMS Energy, RMS Energy Gammatone 1–10
Spectral composition and timbre	Brightness (%), Inharmonicity (%), Highest Peak Frequency (Hz), Roughness, Spectral Centroid (Hz), Spectral Entropy, Spectral Flatness, Spectral Kurtosis, Spectral Rolloff (Hz), Tonal Energy (%), Zero-crossing Rate (per second)
Envelope and temporal distribution	Envelope Flatness, Envelope Kurtosis, Envelope Quantile Range, First Attack Leap, First Attack Slope, First Attack Time (second), First Attack Time Gammatone 1-10 (second), Length Trimmed (sec), Low Energy (%), Release Time (second), Release Time Gammatone 1-10 (second)
MFCC	MFCC 1–13
Spectro-temporal composition	Harmonic Energy (RMS), Percussive Energy (RMS), Melodic Contour, Spectral Flux (Median)

Table 8: Overview of the signal descriptors.

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SUGGESTED CITATION

Herbst, J.-P., Reuter, C. and Czedik-Eysenberg, I. (2018),'Guitar profiling technology in metal music production: Public reception, capability, consequences and perspectives', *Metal Music Studies*, 4:3, pp. 481–506, doi: 10.1386/mms.4.3.481_1

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Volume 4 Number 3
 Appendix. English language. doi: 10.1386/mms.4.3.1_7

SIGNAL DESCRIPTORS

Brightness:

Definition/Algorithm: The spectral 'brightness' as the percentage of spectral energy that exists above a threshold of 1500Hz.
Sources: MIRtoolbox (mirbrightness) (Lartillot et al. 2008).
Interpretation: The higher the value, the more 'bright' and less dull a sound is perceived.

Envelope Flatness:

Definition/Algorithm: The flatness of the temporal envelope. Based on the envelope data, the ratio between the geometric mean and arithmetic mean is calculated.
Sources: MIRtoolbox (mirflatness used on temporal envelope) (Lartillot et al. 2008).
Interpretation: The envelope flatness value shows whether the signal has a flat envelope or contains prominent dynamic peaks.

Envelope Kurtosis:

Definition/Algorithm: (Excess) kurtosis of the temporal envelope (the fourth standardized moment of the temporal distribution).
Sources: MIRtoolbox (mirkurtosis used on temporal envelope) (Lartillot et al. 2008).
Interpretation: The higher the kurtosis, the more steep/pointy is the dynamic progression of the temporal envelope in general, meaning that there is one steep increase and decrease rather than having a signal with a constant level of intensity.

Envelope Quantile Range:

Definition/Algorithm: The range of the temporal envelope (excluding extreme values). In a first step, the envelope is extracted through filtering. For this data, the distance between the 0.9 and 0.2 quantile is calculated to not include extremely high values and occasional silences.
Sources: Specifically developed feature, using the MIRtoolbox (mirenvelope) (Lartillot et al. 2008).
Interpretation: This descriptor provides a certain insight into the (relevant) dynamic range of the recording.

First Attack Leap:

Definition/Algorithm: The amplitude difference between the start and end of the (first) attack phase. The pseudo-silence at the beginning of the recording is trimmed. Then the first occurring attack is detected and its amplitude difference extracted.
Sources: MIRtoolbox (miraudio, mirattackleap) (Lartillot et al. 2008).
Interpretation: The greater the value, the stronger is the contrast between the beginning and end of the attack in terms of the reached amplitude.

First Attack Slope:

Definition/Algorithm: The average slope of the (first) attack phase. Pseudo-silence at the beginning of the audio file is trimmed, and the first attack is detected. For this, the slope is determined as the ratio between the magnitude difference at the beginning and ending of the attack period (=attack leap) and corresponding duration (=attack time): *AttackLeap/AttackTime = AttackSlope.*
Sources: MIRtoolbox (miraudio, mirattackslope) (Lartillot et al. 2008).
Interpretation: A higher value indicates a more abrupt energy increase during the attack phase.

First Attack Time:

Definition/Algorithm: The temporal duration of the (first) attack phase (in seconds). The pseudo-silence at the beginning of the recording is trimmed. Then the first occurring attack is detected, and the time difference between its beginning and its ending is determined.
Sources: MIRtoolbox (miraudio, mirattacktime) (Lartillot et al. 2008).
Interpretation: The greater the value, the longer the attack of the sound lasts.

First Attack Time Gammatone (1–10):

Definition/Algorithm: The individual attack time of specific gammatone filter bands. First the signal is decomposed using a gammatone filter bank (Patterson et al. 1992). For each of the resulting bands, the duration of the (first) attack phase is calculated.
Sources: Specifically developed feature using MIRtoolbox (mirfilterbank, mirattacktime). Gammatone filter bank decomposition is performed using the Auditory Toolbox (MakeERBFilters, ERBfilterbank) (Slaney 1998).
Interpretation: The greater the value is for a specific filter band, the longer the attack time of the signal components in that frequency area lasts.

Harmonic Energy:

Definition/Algorithm: The energy of the 'harmonic' part of the signal. Using median filtering according to Fitzgerald (2010), the signal is split into vertical and horizontal components. The signal part containing the horizontal components (the spectro-temporal pieces that stay constant over the time) then is analysed according to its RMS energy.
Sources: Specifically developed feature using the TSM toolbox (Driedger and Müller 2014) and the MIRtoolbox (Lartillot et al. 2008).
Interpretation: The higher the value, the more pronounced are the rather stationary parts of the signal. These stable parts can be harmonic tones but also a stationary noise, etc.

Highest Peak Frequency:

Definition/Algorithm: The frequency of the highest spectral peak (in Hertz). After detecting all peaks in the spectrum, the most predominant one is selected.
Sources: MIRtoolbox (mirpeaks) (Lartillot et al. 2008) – only the frequency of the highest detected peak is considered.
Interpretation: The strongest frequency in the spectrum. This often (but not always) corresponds to the fundamental frequency of a sound (e.g. with a higher dynamics level, the strongest frequency can shift to a higher partial tone [Schumann 1929]).

Inharmonicity:

Definition/Algorithm: Estimation of the inharmonicity of a sound. Based on a detected fundamental frequency, a filter is constructed representing the ideal harmonic series. The inharmonicity is estimated as the amount of energy existing outside these areas which correspond to multiples of the fundamental frequency.
Sources: MIRtoolbox (mirinharmonicity) (Lartillot et al. 2008).
Interpretation: A higher value (closer to 1) indicates a more inharmonic perception (e.g. white noise would result in a higher inharmonicity value than a harmonic tone).

Length Trimmed:

Definition/Algorithm: Effective duration of the sound (in seconds). First, the pseudo-silence at the beginning and end of the signal is removed. Then the length is determined.
Sources: MIRtoolbox (miraudio, mirlength) (Lartillot et al. 2008).
Interpretation: Time duration during which the recorded sound is actually audible.

Loudness Sone:

Definition/Algorithm: Psychoacoustic loudness of the sound (in Sone). Loudness is being calculated according to the *ANSI S3.4-2007* standard for steady sounds (ANSI 2007) based on the model by Moore et al. (1997).
Sources: Genesis Loudness Toolbox (Genesis 2009).
Interpretation: The higher the value, the louder the signal is perceived (over the course of time).

Low Energy:

Definition/Algorithm: The percentage of frames with an RMS energy value that is less than the average RMS energy across the whole signal.
Sources: MIRtoolbox (mirlowenergy) (Lartillot et al. 2008).
Interpretation: The low-energy rate indicates whether the temporal energy distribution is relatively constant throughout the signal or not. A piece of music with many pauses or silent frames will, for example, have a higher low-energy value than a recording of a continuous string sound (Tzanetakis and Cook 2002).

Maximum RMS Position:

Definition/Algorithm: The temporal position of the maximum RMS energy value (as a frame index). As a first step, pseudo-silence at the beginning is trimmed. From the RMS curve, the time position of the maximum value is then determined.
Sources: Descriptor implemented using MIRtoolbox (mirrms) (Lartillot et al. 2008).
Interpretation: The higher the value, the later the energy maximum appears in the course of the signal.

Maximum RMS Value:

Definition/Algorithm: The maximum RMS energy value. From the RMS energy curve throughout the signal, the maximum value is determined.
Sources: Descriptor implemented using MIRtoolbox (mirrms) (Lartillot et al. 2008).
Interpretation: A high value shows that a high-energy level is reached at least at one point during the signal.

Melodic Contour:

Definition/Algorithm: The melodic/timbral contour of the signal as a general tendency (up, same or down). As a first step, occurring pitches are detected and spectral centroid values are calculated for each frame. Polynomial curve fitting is applied to obtain the overall gradient via least-squares regression.
Sources: Custom algorithm, implemented using the MIRtoolbox (Lartillot et al. 2008).
Interpretation: A positive value says that the pitch or general timbral brightness ascends during the course of the signal, a value close to 0 means that it stays the same, while a negative value indicates a descending contour.

MFCC (1–13):

Definition/Algorithm: Mel-Frequency Cepstral Coefficients. For obtaining the coefficients, a short-term power spectrum is calculated via Discrete Fourier Transform. The frequency axis is transformed via a Mel filter bank to better approximate the human auditory system. By applying a Discrete Cosine Transform (DCT) to the logarithmized spectrum, a cepstrum then is obtained (Zheng et al. 2001). The first thirteen components of the DCT are kept as coefficients.
Sources: MIRtoolbox (mirmfcc) (Lartillot et al. 2008).
Interpretation: MFCCs offer a relatively compact summary of the spectral shape of a sound. They encapsulate information about vocal formants and other timbral characteristics, which is why they are used in speech processing (Han et al. 2006), speaker recognition (Murty and Yegnanarayana 2006), but also in the context of music and timbre similarity (Logan 2000; Pachet and Aucouturier 2004).

Percussive Energy:

Definition/Algorithm: The energy of the 'percussive' signal part. Using median filtering according to Fitzgerald (2010), the signal is split into vertical and horizontal components. The resulting signal part that contains the vertical

components (the spectro-temporal parts that are of short duration but with a broadband frequency response) is then analysed according to its RMS energy.
Sources: Specifically developed feature using the TSM toolbox (Driedger and Müller 2014) and the MIRtoolbox (Lartillot et al. 2008).
Interpretation: The higher the value, the more pronounced are the non-stationary, more abrupt parts of the signal. These fast-changing parts can, for example, be percussive elements (such as drum beats) or the plucking of a string.

Release Time:

Definition/Algorithm: Estimation of the duration of the release phase. The algorithm for extracting the attack time is applied backwards to the signal.
Sources: Specifically developed feature using the MIRtoolbox (Lartillot et al. 2008).
Interpretation: The greater the value, the longer the energy takes to decline.

Release Time Gammatone (1–10):

Definition/Algorithm: Estimation of the duration of the release phase in specific filter bands of a gammatone filter bank (Patterson et al. 1992).
Sources: Specifically developed feature using the MIRtoolbox (Lartillot et al. 2008). Gammatone filter bank decomposition is performed using the Auditory Toolbox (MakeERBFilters, ERBfilterbank) (Slaney 1998).
Interpretation: The greater the value for a specific filter band, the longer the energy takes to decline in that frequency range.

RMS:

Definition/Algorithm: Root-mean-square energy of the signal (the quadratic mean of the amplitude).
Sources: MIRtoolbox (mirrms) (Lartillot et al. 2008).
Interpretation: The global energy of the sound.

RMS Gammatone (1–10):

Definition/Algorithm: Root-mean-square (RMS) energy of a specific gammatone filter band (Patterson et al. 1992).
Sources: Specifically developed feature using the MIRtoolbox (Lartillot et al. 2008). Gammatone filter bank decomposition is performed using the Auditory Toolbox (MakeERBFilters, ERBfilterbank) (Slaney 1998).
Interpretation: The greater the value for a specific filter band, the more pronounced is the energy in that frequency range.

Roughness:

Definition/Algorithm: The estimation of the roughness (=sensory dissonance) of the sound according to Plomp and Levelt (1965). In a first step, sine components are detected in the spectrum by peak selection. Then the roughness is calculated by analysing the frequency ratio of all possible pairs of sinusoids and summarizing the result (Sethares 2005).
Sources: MIRtoolbox (mirroughness) (Lartillot et al. 2008).

Interpretation: The greater the value, the more intense is the overall roughness sensation of the sound.

Spectral Centroid:

Definition/Algorithm: The geometric centre of the spectrum (as a statistical moment for describing the spectral distribution). In this case, the spectral centroid is calculated based on the magnitude spectrum (not based on the power spectrum).
Sources: MIRtoolbox (mircentroid) (Lartillot et al. 2008).
Interpretation: The Spectral Centroid has been shown to be associated with the psychoacoustic dimension of 'brightness' or 'sharpness' (Grey and Gordon 1978; Schubert et al. 2004; Schubert and Wolfe 2006).

Spectral Entropy:

Definition/Algorithm: The relative Shannon entropy of the spectrum as a statistical descriptor of the spectral distribution.
Sources: MIRtoolbox (mirentropy) (Lartillot et al. 2008).
Interpretation: The spectral entropy indicates, whether the spectrum is dominated by pronounced, isolated peaks or is rather flat and uniform. The greater the value is (with 1 as a maximum), the flatter (similar to noise) the curve is. On the other hand, if the signal is dominated by a single prominent peak (like in the case of a pure tone), it would result in a lower entropy value.

Spectral Flatness:

Definition/Algorithm: Flatness of the spectrum. The ratio between the geometric mean and arithmetic mean of the spectral distribution.
Sources: MIRtoolbox (mirflatness) (Lartillot et al. 2008).
Interpretation: The spectral flatness indicates whether the spectrum is rather smooth or spiky (e.g. because of a predominant fundamental frequency). As an example, white noise would have a higher spectral flatness value than a pure tone.

Spectral Flux Median:

Definition/Algorithm: Spectral fluctuations (the median distance between the spectrum of successive frames). For each frame, the Euclidean distance to the next frame is calculated. Then, the median of all values is determined.
Sources: MIRtoolbox (mirflux) (Lartillot et al. 2008) – aggregated by median.
Interpretation: A high median spectral flux shows that there might be many timbral changes (especially caused by onsets [Dixon 2006], speech or other quickly changing sounds) in the given time frame.

Spectral Kurtosis:

Definition/Algorithm: The (excess) kurtosis of the spectrum (the fourth standardized moment of the spectral distribution).
Sources: MIRtoolbox (mirkurtosis) (Lartillot et al. 2008).
Interpretation: The value indicates whether the spectrum is more convex than a normal distribution. The higher the value, the more pointy the spectrum. For instance, for a sound with a predominant fundamental frequency, the kurtosis value will usually be higher than for white noise.

Spectral Rolloff:

Definition/Algorithm: The frequency threshold (in Hertz), so that 85 per cent of the total energy is contained below that threshold. The limit of 85 per cent was proposed by Tzanetakis and Cook (2002).
Sources: MIRtoolbox (mirrolloff) (Lartillot et al. 2008).
Interpretation: The spectral rolloff is an indicator for the amount of high frequency energy in the signal (the higher the value, the less dull the signal might sound).

Tonal Energy:

Definition/Algorithm: The amount of energy inside the ideal harmonic series. In a first step, the fundamental pitch of the signal is detected. Based on that frequency, a filter representing the ideal harmonic series is constructed. The tonal energy is estimated as the percentage of energy inside the frequency bands that are concordant with the multiples of the fundamental frequency.
Sources: Specifically developed feature using the MIRtoolbox (mirpitch, mirinharmonicity) (Lartillot et al. 2008).
Interpretation: A high tonal energy value indicates that the signal resembles a simple harmonic tone rather than a noisy, more complex sound.

Zero-Crossing Rate:

Definition/Algorithm: The number of times the signal crosses the x-axis in a given period of time. Every change of sign from negative to positive is counted.
Sources: MIRtoolbox (mirzerocross) (Lartillot et al. 2008).
Interpretation: The zero-crossing rate is an indicator of the noisiness of a sound, as it tends to be smaller for periodic sounds than, for example, for white noise (Peeters et al. 2011: 2906).

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Metal Music Studies
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© 2018 Intellect Ltd Appendix. English language. doi: 10.1386/mms.4.3.9_7

DETAILED STATISTICAL DATA COMPARING ORIGINAL AMPLIFIERS WITH PROFILED COPIES

Notes on data interpretation

- Significant mean differences exist with 'Sig.' smaller than 0.005.
- The strength of the effect can be estimated with the (partial) Eta squared. According to Cohen (1988), there are three ranges of effect sizes: small (0.01), medium (0.06) and large (0.14). The values cannot be larger than 1.

ANOVA table of total sample (without test tones)

		Sum of squares	df	Mean square	F	Sig.	η	η²
brightness	Between groups	0.014	1	0.014	0.340	0.560	0.021	0.000
	Within groups	54.490	1342	0.041			0.004	0.000
	Total	54.504	1343				0.038	0.001
entropy	Between groups	0.001	1	0.001	0.252	0.616	0.016	0.000
	Within groups	7.143	1342	0.005			0.005	0.000
	Total	7.144	1343				0.065	0.004
envelopeFlatness	Between groups	0.085	1	0.085	1.076	0.300	0.031	0.001
	Within groups	105.685	1342	0.079			0.093	0.009
	Total	105.769	1343				0.066	0.004
envelopeKurtosis	Between groups	48.152	1	48.152	0.338	0.561	0.087	0.008
	Within groups	190,893.735	1341	142.352			0.062	0.004
	Total	190,941.887	1342				0.012	0.000
envelopeQuantile Range	Between groups	0.000	1	0.000	0.001	0.976	0.027	0.001
	Within groups	14.719	1342	0.011			0.010	0.000
	Total	14.719	1343				0.008	0.000
firstAttackLeap	Between groups	0.442	1	0.442	14.371	0.000	0.008	0.000
	Within groups	41.297	1342	0.031			0.013	0.000
	Total	41.739	1343				0.155	0.024
firstAttackSlope	Between groups	1027.396	1	1027.396	3.444	0.064	0.013	0.000
	Within groups	400,285.707	1342	298.275			0.025	0.001
	Total	401,313.103	1343				0.040	0.002

		Sum of squares	df	Mean square	F	Sig.	η	η²
firstAttackTime	Between groups	0.005	1	0.005	4.757	0.029	0.036	0.001
	Within groups	1.410	1342	0.001			0.032	0.001
	Total	1.415	1343				0.039	0.001
firstAttackTime Gammatone1	Between groups	0.003	1	0.003	4.237	0.040	0.020	0.000
	Within groups	0.950	1342	0.001			0.026	0.001
	Total	0.953	1343				0.009	0.000
firstAttackTime Gammatone2	Between groups	0.007	1	0.007	7.753	0.005	0.035	0.001
	Within groups	1.148	1342	0.001			0.099	0.010
	Total	1.155	1343				0.094	0.009
firstAttackTime Gammatone3	Between groups	0.003	1	0.003	3.585	0.059	0.310	0.096
	Within groups	1.102	1342	0.001			0.081	0.007
	Total	1.104	1343				0.067	0.004
firstAttackTime Gammatone4	Between groups	0.001	1	0.001	0.605	0.437	0.007	0.000
	Within groups	1.217	1342	0.001			0.192	0.037
	Total	1.217	1343				0.487	0.237
firstAttackTime Gammatone5	Between groups	0.001	1	0.001	1.292	0.256	0.223	0.050
	Within groups	1.291	1342	0.001			0.045	0.002
	Total	1.292	1343				0.148	0.022
firstAttackTime Gammatone6	Between groups	0.000	1	0.000	0.023	0.879	0.208	0.043
	Within groups	0.822	1342	0.001			0.011	0.000
	Total	0.822	1343				0.040	0.002
firstAttackTime Gammatone7	Between groups	0.000	1	0.000	0.190	0.663	0.041	0.002
	Within groups	1.147	1342	0.001			0.025	0.001
	Total	1.148	1343				0.005	0.000
firstAttackTime Gammatone8	Between groups	0.000	1	0.000	0.197	0.658	0.056	0.003
	Within groups	1.163	1342	0.001			0.069	0.005
	Total	1.164	1343				0.045	0.002
firstAttackTime Gammatone9	Between groups	0.001	1	0.001	0.438	0.508	0.100	0.010
	Within groups	2.008	1342	0.001			0.154	0.024
	Total	2.008	1343				0.022	0.000
firstAttackTime Gammatone10	Between groups	0.042	1	0.042	23.905	0.000	0.083	0.007
	Within groups	2.333	1342	0.002			0.024	0.001
	Total	2.375	1343				0.297	0.088
harmonicEnergy	Between groups	0.003	1	0.003	0.332	0.564	0.057	0.003
	Within groups	12.948	1342	0.010			0.029	0.001
	Total	12.952	1343				0.066	0.004
highestPeak Frequency	Between groups	1,637,404.402	1	1,637,404.402	19.249	0.000	0.091	0.008
	Within groups	114,156,716.072	1342	85,064.617			0.010	0.000
	Total	115,794,120.473	1343				0.043	0.002

		Sum of squares	df	Mean square	F	Sig.	η	η^2
inharmonicity	Between groups	0.013	1	0.013	1.780	0.182	0.046	0.002
	Within groups	9.670	1310	0.007			0.097	0.009
	Total	9.683	1311				0.010	0.000
lengthTrimmed	Between groups	56.217	1	56.217	1.217	0.270	0.036	0.001
	Within groups	62,013.776	1342	46.210			0.026	0.001
	Total	62,069.993	1343				0.151	0.023
loudnessSone	Between groups	231.607	1	231.607	1.537	0.215	0.005	0.000
	Within groups	202,240.620	1342	150.701			0.007	0.000
	Total	202,472.227	1343				0.020	0.000
lowEnergy	Between groups	0.016	1	0.016	0.394	0.530	0.041	0.002
	Within groups	54.099	1342	0.040			0.015	0.000
	Total	54.115	1343				0.021	0.000
maxRmsPosition	Between groups	5704.882	1	5704.882	0.431	0.512	0.004	0.000
	Within groups	17,773,725.576	1342	13,244.207			0.038	0.001
	Total	17,779,430.458	1343				0.016	0.000
maxRmsValue	Between groups	0.017	1	0.017	1.518	0.218	0.005	0.000
	Within groups	14.674	1342	0.011			0.065	0.004
	Total	14.691	1343				0.031	0.001
melodiccontour Comb	Between groups	150.863	1	150.863	1.227	0.268	0.093	0.009
	Within groups	164,992.240	1342	122.945			0.066	0.004
	Total	165,143.102	1343				0.087	0.008
mfcc1	Between groups	0.179	1	0.179	0.083	0.773	0.062	0.004
	Within groups	2886.064	1342	2.151			0.012	0.000
	Total	2886.243	1343				0.027	0.001
mfcc2	Between groups	2.131	1	2.131	7.902	0.005	0.010	0.000
	Within groups	361.971	1342	0.270			0.008	0.000
	Total	364.102	1343				0.008	0.000
mfcc3	Between groups	0.296	1	0.296	5.551	0.019	0.013	0.000
	Within groups	71.481	1342	0.053			0.155	0.024
	Total	71.776	1343				0.013	0.000
mfcc4	Between groups	3.959	1	3.959	137.084	0.000	0.025	0.001
	Within groups	38.754	1342	0.029			0.040	0.002
	Total	42.713	1343				0.036	0.001
mfcc5	Between groups	0.526	1	0.526	13.074	0.000	0.032	0.001
	Within groups	53.997	1342	0.040			0.039	0.001
	Total	54.523	1343				0.020	0.000
mfcc6	Between groups	0.337	1	0.337	6.891	0.009	0.026	0.001
	Within groups	65.696	1342	0.049			0.009	0.000
	Total	66.033	1343				0.035	0.001

		Sum of squares	df	Mean square	F	Sig.	η	η^2
mfcc7	Between groups	0.013	1	0.013	0.250	0.617	0.099	0.010
	Within groups	70.023	1342	0.052			0.094	0.009
	Total	70.036	1343				0.310	0.096
mfcc8	Between groups	1.307	1	1.307	63.919	0.000	0.081	0.007
	Within groups	27.431	1342	0.020			0.067	0.004
	Total	28.738	1343				0.007	0.000
mfcc9	Between groups	9.080	1	9.080	438.349	0.000	0.192	0.037
	Within groups	27.798	1342	0.021			0.487	0.237
	Total	36.878	1343				0.223	0.050
mfcc10	Between groups	4.342	1	4.342	79.050	0.000	0.045	0.002
	Within groups	73.707	1342	0.055			0.148	0.022
	Total	78.048	1343				0.208	0.043
mfcc11	Between groups	0.151	1	0.151	3.223	0.073	0.011	0.000
	Within groups	62.677	1342	0.047			0.040	0.002
	Total	62.827	1343				0.041	0.002
mfcc12	Between groups	0.416	1	0.416	37.526	0.000	0.025	0.001
	Within groups	14.890	1342	0.011			0.005	0.000
	Total	15.306	1343				0.056	0.003
mfcc13	Between groups	0.541	1	0.541	76.194	0.000	0.069	0.005
	Within groups	9.529	1342	0.007			0.045	0.002
	Total	10.070	1343				0.100	0.010
percussive Energy	Between groups	0.000	1	0.000	0.127	0.722	0.154	0.024
	Within groups	1.349	1342	0.001			0.022	0.000
	Total	1.349	1343				0.083	0.007
releaseTime	Between groups	0.015	1	0.015	1.583	0.209	0.024	0.001
	Within groups	12.307	1342	0.009			0.297	0.088
	Total	12.321	1343				0.057	0.003
releaseTime Gammatone1	Between groups	0.004	1	0.004	2.151	0.143	0.029	0.001
	Within groups	2.458	1342	0.002			0.066	0.004
	Total	2.462	1343				0.091	0.008
releaseTime Gammatone2	Between groups	0.003	1	0.003	0.498	0.481	0.010	0.000
	Within groups	7.160	1342	0.005			0.043	0.002
	Total	7.163	1343				0.046	0.002
releaseTime Gammatone3	Between groups	0.000	1	0.000	0.010	0.921	0.097	0.009
	Within groups	14.754	1342	0.011			0.010	0.000
	Total	14.754	1343				0.036	0.001
releaseTime Gammatone4	Between groups	0.016	1	0.016	3.876	0.049	0.026	0.001
	Within groups	5.399	1342	0.004			0.151	0.023
	Total	5.415	1343				0.005	0.000

		Sum of squares	df	Mean square	F	Sig.	η	$η^2$
releaseTime Gammatone5	Between groups	0.022	1	0.022	5.233	0.022	0.007	0.000
	Within groups	5.744	1342	0.004			0.020	0.000
	Total	5.766	1343				0.041	0.002
releaseTime Gammatone6	Between groups	0.010	1	0.010	2.206	0.138	0.015	0.000
	Within groups	6.333	1342	0.005			0.021	0.000
	Total	6.343	1343				0.004	0.000
releaseTime Gammatone7	Between groups	0.039	1	0.039	9.876	0.002	0.038	0.001
	Within groups	5.347	1342	0.004			0.016	0.000
	Total	5.386	1343				0.005	0.000
releaseTime Gammatone8	Between groups	0.071	1	0.071	24.242	0.000	0.065	0.004
	Within groups	3.924	1342	0.003			0.031	0.001
	Total	3.995	1343				0.093	0.009
releaseTime Gammatone9	Between groups	0.000	1	0.000	0.068	0.795	0.066	0.004
	Within groups	4.435	1342	0.003			0.087	0.008
	Total	4.435	1343				0.062	0.004
releaseTime Gammatone10	Between groups	0.039	1	0.039	8.273	0.004	0.012	0.000
	Within groups	6.388	1342	0.005			0.027	0.001
	Total	6.427	1343				0.010	0.000
rms	Between groups	0.015	1	0.015	1.561	0.212	0.008	0.000
	Within groups	12.925	1342	0.010			0.008	0.000
	Total	12.940	1343				0.013	0.000
rmsGammatone1	Between groups	0.002	1	0.002	111.595	0.000	0.155	0.024
	Within groups	0.030	1342	0.000			0.013	0.000
	Total	0.032	1343				0.025	0.001
rmsGammatone2	Between groups	0.012	1	0.012	3.072	0.080	0.040	0.002
	Within groups	5.144	1342	0.004			0.036	0.001
	Total	5.156	1343				0.032	0.001
rmsGammatone3	Between groups	0.000	1	0.000	0.641	0.423	0.039	0.001
	Within groups	0.943	1342	0.001			0.020	0.000
	Total	0.943	1343				0.026	0.001
rmsGammatone4	Between groups	0.001	1	0.001	5.752	0.017	0.009	0.000
	Within groups	0.148	1342	0.000			0.035	0.001
	Total	0.148	1343				0.099	0.010
rmsGammatone5	Between groups	0.000	1	0.000	8.189	0.004	0.094	0.009
	Within groups	0.067	1342	0.000			0.310	0.096
	Total	0.068	1343				0.081	0.007
rmsGammatone6	Between groups	0.000	1	0.000	0.002	0.964	0.067	0.004
	Within groups	0.369	1342	0.000			0.007	0.000
	Total	0.369	1343				0.192	0.037

		Sum of squares	df	Mean square	F	Sig.	η	η²
rmsGammatone7	Between groups	0.000	1	0.000	1.012	0.315	0.487	0.237
	Within groups	0.336	1342	0.000			0.223	0.050
	Total	0.336	1343				0.045	0.002
rmsGammatone8	Between groups	0.000	1	0.000	1.908	0.167	0.148	0.022
	Within groups	0.054	1342	0.000			0.208	0.043
	Total	0.054	1343				0.011	0.000
rmsGammatone9	Between groups	0.000	1	0.000	3.417	0.065	0.040	0.002
	Within groups	0.006	1342	0.000			0.041	0.002
	Total	0.006	1343				0.025	0.001
rmsGammatone10	Between groups	0.000	1	0.000	1.067	0.302	0.005	0.000
	Within groups	0.001	1342	0.000			0.056	0.003
	Total	0.001	1343				0.069	0.005
roughness	Between groups	40,179,612.755	1	40,179,612.755	1.651	0.199	0.045	0.002
	Within groups	32,654,489,580.378	1342	24,332,704.605			0.100	0.010
	Total	32,694,669,193.133	1343				0.154	0.024
spectralCentroid	Between groups	1,974,296.609	1	1,974,296.609	2.924	0.088	0.022	0.000
	Within groups	906,246,171.492	1342	675,295.210			0.083	0.007
	Total	908,220,468,101	1343				0.024	0.001
spectralFlatness	Between groups	0.016	1	0.016	12.935	0.000	0.297	0.088
	Within groups	1.675	1342	0.001			0.057	0.003
	Total	1.691	1343				0.029	0.001
spectral FluxMedian	Between groups	243.433	1	243.433	0.062	0.803	0.066	0.004
	Within groups	5,235,617.732	1342	3901.354			0.091	0.008
	Total	5,235,861.166	1343				0.010	0.000
spectralKurtosis	Between groups	55.734	1	55.734	0.066	0.797	0.043	0.002
	Within groups	1,128,599.193	1342	840.983			0.046	0.002
	Total	1,128,654.926	1343				0.097	0.009
spectralRolloff	Between groups	734,744.979	1	734,744.979	0.461	0.497	0.010	0.000
	Within groups	2,140,716,871.229	1342	1,595,169.055			0.036	0.001
	Total	2,141,451,616.208	1343				0.026	0.001
tonalEnergy	Between groups	0.014	1	0.014	1.869	0.172	0.151	0.023
	Within groups	9.689	1310	0.007			0.005	0.000
	Total	9.703	1311				0.007	0.000
zeroCrossing Rate	Between groups	89,065.964	1	89,065.964	0.154	0.695	0.020	0.000
	Within groups	778,503,128.409	1342	580,106.653			0.041	0.002
	Total	778,592,194.373	1343				0.015	0.000

ANOVA table of clean guitar sounds

		Sum of squares	df	Mean square	F	Sig.	η	η^2
brightness	Between groups	0.007	1	0.007	0.114	0.735	0.024	0.001
	Within groups	28.849	446	0.065			0.003	0.000
	Total	28.856	447				0.027	0.001
entropy	Between groups	0.000	1	0.000	0.049	0.825	0.017	0.000
	Within groups	3.397	446	0.008			0.158	0.025
	Total	3.397	447				0.021	0.000
envelopeFlatness	Between groups	0.003	1	0.003	0.066	0.798	0.034	0.001
	Within groups	22.500	446	0.050			0.042	0.002
	Total	22.504	447				0.002	0.000
envelopeKurtosis	Between groups	41.920	1	41.920	0.195	0.659	0.007	0.000
	Within groups	95,451.393	445	214.498			0.020	0.000
	Total	95,493.313	446				0.036	0.001
envelopeQuantile Range	Between groups	0.025	1	0.025	7.847	0.005	0.101	0.010
	Within groups	1.399	446	0.003			0.086	0.007
	Total	1.423	447				0.090	0.008
firstAttackLeap	Between groups	0.000	1	0.000	0.111	0.739	0.083	0.007
	Within groups	1.767	446	0.004			0.121	0.015
	Total	1.767	447				0.157	0.025
firstAttackSlope	Between groups	946.029	1	946.029	1.656	0.199	0.219	0.048
	Within groups	254,783.209	446	571.263			0.055	0.003
	Total	255,729.237	447				0.028	0.001
firstAttackTime	Between groups	0.000	1	0.000	0.064	0.800	0.085	0.007
	Within groups	0.610	446	0.001			0.266	0.071
	Total	0.610	447				0.031	0.001
firstAttackTime Gammatone1	Between groups	0.000	1	0.000	0.018	0.894	0.054	0.003
	Within groups	0.322	446	0.001			0.316	0.100
	Total	0.322	447				0.031	0.001
firstAttackTime Gammatone2	Between groups	0.000	1	0.000	0.000	0.986	0.073	0.005
	Within groups	0.374	446	0.001			0.081	0.007
	Total	0.374	447				0.021	0.000
firstAttackTime Gammatone3	Between groups	0.000	1	0.000	0.198	0.656	0.271	0.074
	Within groups	0.526	446	0.001			0.174	0.030
	Total	0.526	447				0.058	0.003
firstAttackTime Gammatone4	Between groups	0.001	1	0.001	0.395	0.530	0.031	0.001
	Within groups	0.600	446	0.001			0.262	0.069
	Total	0.601	447				0.481	0.231
firstAttackTime Gammatone5	Between groups	0.003	1	0.003	2.728	0.099	0.319	0.102
	Within groups	0.529	446	0.001			0.130	0.017
	Total	0.533	447				0.221	0.049

		Sum of squares	df	Mean square	F	Sig.	η	$η^2$
firstAttackTime Gammatone6	Between groups	0.001	1	0.001	2.186	0.140	0.041	0.002
	Within groups	0.305	446	0.001			0.223	0.050
	Total	0.307	447				0.029	0.001
firstAttackTime Gammatone7	Between groups	0.002	1	0.002	2.563	0.110	0.098	0.010
	Within groups	0.280	446	0.001			0.124	0.015
	Total	0.282	447				0.029	0.001
firstAttackTime Gammatone8	Between groups	0.002	1	0.002	2.367	0.125	0.129	0.017
	Within groups	0.318	446	0.001			0.041	0.002
	Total	0.319	447				0.002	0.000
firstAttackTime Gammatone9	Between groups	0.007	1	0.007	4.376	0.037	0.187	0.035
	Within groups	0.690	446	0.002			0.327	0.107
	Total	0.697	447				0.081	0.007
firstAttackTime Gammatone10	Between groups	0.016	1	0.016	7.711	0.006	0.121	0.015
	Within groups	0.897	446	0.002			0.244	0.060
	Total	0.913	447				0.023	0.001
harmonicEnergy	Between groups	0.007	1	0.007	3.941	0.048	0.013	0.000
	Within groups	0.843	446	0.002			0.114	0.013
	Total	0.850	447				0.233	0.054
highestPeak Frequency	Between groups	926,103.382	1	926,103.382	7.749	0.006	0.276	0.076
	Within groups	53,303,738.412	446	119,515.109			0.143	0.020
	Total	54,229,841.794	447				0.141	0.020
inharmonicity	Between groups	0.001	1	0.001	0.235	0.628	0.115	0.013
	Within groups	2.352	446	0.005			0.001	0.000
	Total	2.353	447				0.073	0.005
lengthTrimmed	Between groups	55.560	1	55.560	2.372	0.124	0.199	0.039
	Within groups	10,445.384	446	23.420			0.071	0.005
	Total	10,500.943	447				0.220	0.048
loudnessSone	Between groups	502.688	1	502.688	4.064	0.044	0.087	0.007
	Within groups	55,173.433	446	123.707			0.189	0.036
	Total	55,676.121	447				0.042	0.002
lowEnergy	Between groups	0.000	1	0.000	0.001	0.971	0.034	0.001
	Within groups	15.378	446	0.034			0.125	0.016
	Total	15.378	447				0.024	0.001
maxRmsPosition	Between groups	32.681	1	32.681	0.085	0.771	0.003	0.000
	Within groups	172,421.192	446	386.595			0.027	0.001
	Total	172,453.873	447				0.017	0.000
maxRmsValue	Between groups	0.085	1	0.085	12.818	0.000	0.158	0.025
	Within groups	2.962	446	0.007			0.021	0.000
	Total	3.047	447				0.034	0.001

		Sum of squares	df	Mean square	F	Sig.	η	η^2
melodiccontour Comb	Between groups	65.118	1	65.118	0.573	0.450	0.042	0.002
	Within groups	50,706.628	446	113.692			0.002	0.000
	Total	50,771.745	447				0.007	0.000
mfcc1	Between groups	0.069	1	0.069	0.019	0.890	0.020	0.000
	Within groups	1626.278	446	3.646			0.036	0.001
	Total	1626.347	447				0.101	0.010
mfcc2	Between groups	1.532	1	1.532	2.589	0.108	0.086	0.007
	Within groups	263.967	446	0.592			0.090	0.008
	Total	265.499	447				0.083	0.007
mfcc3	Between groups	0.012	1	0.012	0.192	0.661	0.121	0.015
	Within groups	26.897	446	0.060			0.157	0.025
	Total	26.909	447				0.219	0.048
mfcc4	Between groups	1.262	1	1.262	33.953	0.000	0.055	0.003
	Within groups	16.575	446	0.037			0.028	0.001
	Total	17.837	447				0.085	0.007
mfcc5	Between groups	1.052	1	1.052	15.361	0.000	0.266	0.071
	Within groups	30.554	446	0.069			0.031	0.001
	Total	31.607	447				0.054	0.003
mfcc6	Between groups	0.076	1	0.076	1.479	0.225	0.316	0.100
	Within groups	23.035	446	0.052			0.031	0.001
	Total	23.111	447				0.073	0.005
mfcc7	Between groups	0.036	1	0.036	0.394	0.530	0.081	0.007
	Within groups	40.402	446	0.091			0.021	0.000
	Total	40.438	447				0.271	0.074
mfcc8	Between groups	0.960	1	0.960	36.453	0.000	0.174	0.030
	Within groups	11.749	446	0.026			0.058	0.003
	Total	12.709	447				0.031	0.001
mfcc9	Between groups	3.040	1	3.040	142.763	0.000	0.262	0.069
	Within groups	9.496	446	0.021			0.481	0.231
	Total	12.535	447				0.319	0.102
mfcc10	Between groups	2.991	1	2.991	50.102	0.000	0.130	0.017
	Within groups	26.625	446	0.060			0.221	0.049
	Total	29.616	447				0.041	0.002
mfcc11	Between groups	0.148	1	0.148	6.142	0.014	0.223	0.050
	Within groups	10.743	446	0.024			0.029	0.001
	Total	10.891	447				0.098	0.010
mfcc12	Between groups	0.524	1	0.524	23.309	0.000	0.124	0.015
	Within groups	10.034	446	0.022			0.029	0.001
	Total	10.559	447				0.129	0.017

		Sum of squares	df	Mean square	F	Sig.	η	$η^2$
mfcc13	Between groups	0.023	1	0.023	1.838	0.176	0.041	0.002
	Within groups	5.670	446	0.013			0.002	0.000
	Total	5.693	447				0.187	0.035
percussiveEnergy	Between groups	0.000	1	0.000	0.000	0.997	0.327	0.107
	Within groups	0.457	446	0.001			0.081	0.007
	Total	0.457	447				0.121	0.015
releaseTime	Between groups	0.003	1	0.003	0.268	0.605	0.244	0.060
	Within groups	5.722	446	0.013			0.023	0.001
	Total	5.726	447				0.013	0.000
releaseTime Gammatone1	Between groups	0.007	1	0.007	3.926	0.048	0.114	0.013
	Within groups	0.831	446	0.002			0.233	0.054
	Total	0.838	447				0.276	0.076
releaseTime Gammatone2	Between groups	0.033	1	0.033	6.005	0.015	0.143	0.020
	Within groups	2.462	446	0.006			0.141	0.020
	Total	2.495	447				0.115	0.013
releaseTime Gammatone3	Between groups	0.004	1	0.004	0.305	0.581	0.001	0.000
	Within groups	6.328	446	0.014			0.073	0.005
	Total	6.333	447				0.199	0.039
releaseTime Gammatone4	Between groups	0.041	1	0.041	5.956	0.015	0.071	0.005
	Within groups	3.083	446	0.007			0.220	0.048
	Total	3.124	447				0.087	0.007
releaseTime Gammatone5	Between groups	0.003	1	0.003	0.615	0.433	0.189	0.036
	Within groups	1.828	446	0.004			0.042	0.002
	Total	1.830	447				0.034	0.001
releaseTime Gammatone6	Between groups	0.000	1	0.000	0.004	0.951	0.125	0.016
	Within groups	4.090	446	0.009			0.024	0.001
	Total	4.090	447				0.003	0.000
releaseTime Gammatone7	Between groups	0.033	1	0.033	9.639	0.002	0.027	0.001
	Within groups	1.515	446	0.003			0.017	0.000
	Total	1.548	447				0.158	0.025
releaseTime Gammatone8	Between groups	0.158	1	0.158	37.820	0.000	0.021	0.000
	Within groups	1.863	446	0.004			0.034	0.001
	Total	2.021	447				0.042	0.002
releaseTime Gammatone9	Between groups	0.002	1	0.002	0.953	0.330	0.002	0.000
	Within groups	1.127	446	0.003			0.007	0.000
	Total	1.129	447				0.020	0.000
releaseTime Gammatone10	Between groups	0.024	1	0.024	6.511	0.011	0.036	0.001
	Within groups	1.660	446	0.004			0.101	0.010
	Total	1.685	447				0.086	0.007

		Sum of squares	df	Mean square	F	Sig.	η	η²
rms	Between groups	0.026	1	0.026	7.688	0.006	0.090	0.008
	Within groups	1.490	446	0.003			0.083	0.007
	Total	1.516	447				0.121	0.015
rmsGammatone1	Between groups	0.000	1	0.000	0.635	0.426	0.157	0.025
	Within groups	0.001	446	0.000			0.219	0.048
	Total	0.001	447				0.055	0.003
rmsGammatone2	Between groups	0.000	1	0.000	0.013	0.910	0.028	0.001
	Within groups	0.186	446	0.000			0.085	0.007
	Total	0.186	447				0.266	0.071
rmsGammatone3	Between groups	0.000	1	0.000	6.508	0.011	0.031	0.001
	Within groups	0.029	446	0.000			0.054	0.003
	Total	0.029	447				0.316	0.100
rmsGammatone4	Between groups	0.001	1	0.001	19.752	0.000	0.031	0.001
	Within groups	0.016	446	0.000			0.073	0.005
	Total	0.017	447				0.081	0.007
rmsGammatone5	Between groups	0.000	1	0.000	9.980	0.002	0.021	0.000
	Within groups	0.012	446	0.000			0.271	0.074
	Total	0.013	447				0.174	0.030
rmsGammatone6	Between groups	0.000	1	0.000	0.002	0.966	0.058	0.003
	Within groups	0.118	446	0.000			0.031	0.001
	Total	0.118	447				0.262	0.069
rmsGammatone7	Between groups	0.000	1	0.000	1.241	0.266	0.481	0.231
	Within groups	0.178	446	0.000			0.319	0.102
	Total	0.179	447				0.130	0.017
rmsGammatone8	Between groups	0.000	1	0.000	2.482	0.116	0.221	0.049
	Within groups	0.040	446	0.000			0.041	0.002
	Total	0.040	447				0.223	0.050
rmsGammatone9	Between groups	0.000	1	0.000	3.657	0.056	0.029	0.001
	Within groups	0.006	446	0.000			0.098	0.010
	Total	0.006	447				0.124	0.015
rmsGammatone10	Between groups	0.000	1	0.000	2.398	0.122	0.029	0.001
	Within groups	0.001	446	0.000			0.129	0.017
	Total	0.001	447				0.041	0.002
roughness	Between groups	104,660,614.962	1	104,660,614.962	2.033	0.155	0.002	0.000
	Within groups	22,959,820,250.159	446	51,479,417.601			0.187	0.035
	Total	23,064,480,865.120	447				0.327	0.107
spectralCentroid	Between groups	3,520,400.295	1	3,520,400.295	2.749	0.098	0.081	0.007
	Within groups	571,196,794.122	446	1,280,710.301			0.121	0.015
	Total	574,717,194.417	447				0.244	0.060

		Sum of squares	df	Mean square	F	Sig.	η	η²
spectralFlatness	Between groups	0.028	1	0.028	10.843	0.001	0.023	0.001
	Within groups	1.152	446	0.003			0.013	0.000
	Total	1.180	447				0.114	0.013
spectralFluxMedian	Between groups	1718.949	1	1718.949	0.454	0.501	0.233	0.054
	Within groups	1,686,801.293	446	3782.066			0.276	0.076
	Total	1,688,520.242	447				0.143	0.020
spectralKurtosis	Between groups	13,759.408	1	13,759.408	10.724	0.001	0.141	0.020
	Within groups	572,240.803	446	1283.051			0.115	0.013
	Total	586,000.211	447				0.001	0.000
spectralRolloff	Between groups	2,244,489.508	1	2,244,489.508	0.758	0.385	0.073	0.005
	Within groups	1,321,115,527.254	446	2,962,142.438			0.199	0.039
	Total	1,323,360,016.762	447				0.071	0.005
tonalEnergy	Between groups	0.002	1	0.002	0.339	0.561	0.220	0.048
	Within groups	2.365	446	0.005			0.087	0.007
	Total	2.367	447				0.189	0.036
zeroCrossingRate	Between groups	1,783,241.396	1	1,783,241.396	2.027	0.155	0.042	0.002
	Within groups	392,313,723.272	446	879,627.182			0.034	0.001
	Total	394,096,964.668	447				0.125	0.016

ANOVA table of overdriven guitar sounds

		Sum of squares	df	Mean square	F	Sig.	η	η²
brightness	Between groups	0.002	1	0.002	0.050	0.823	0.050	0.003
	Within groups	15.159	446	0.034			0.015	0.000
	Total	15.161	447				0.050	0.003
entropy	Between groups	0.000	1	0.000	0.017	0.897	0.013	0.000
	Within groups	1.776	446	0.004			0.109	0.012
	Total	1.777	447				0.110	0.012
envelopeFlatness	Between groups	0.032	1	0.032	0.428	0.513	0.049	0.002
	Within groups	33.409	446	0.075			0.177	0.031
	Total	33.441	447				0.109	0.012
envelopeKurtosis	Between groups	12.814	1	12.814	0.096	0.757	0.066	0.004
	Within groups	59,701.558	446	133.860			0.097	0.009
	Total	59,714.372	447				0.087	0.008
envelope QuantileRange	Between groups	0.012	1	0.012	1.394	0.238	0.061	0.004
	Within groups	3.950	446	0.009			0.010	0.000
	Total	3.962	447				0.084	0.007
firstAttackLeap	Between groups	0.214	1	0.214	17.250	0.000	0.008	0.000
	Within groups	5.536	446	0.012			0.022	0.000
	Total	5.750	447				0.182	0.033

		Sum of squares	df	Mean square	F	Sig.	η	η^2
firstAttackSlope	Between groups	200.388	1	200.388	1.288	0.257	0.032	0.001
	Within groups	69,397.410	446	155.600			0.002	0.000
	Total	69,597.799	447				0.042	0.002
firstAttackTime	Between groups	0.003	1	0.003	4.100	0.043	0.027	0.001
	Within groups	0.303	446	0.001			0.015	0.000
	Total	0.305	447				0.023	0.001
firstAttackTime Gammatone1	Between groups	0.002	1	0.002	3.605	0.058	0.033	0.001
	Within groups	0.286	446	0.001			0.138	0.019
	Total	0.288	447				0.007	0.000
firstAttackTime Gammatone2	Between groups	0.001	1	0.001	1.641	0.201	0.050	0.003
	Within groups	0.345	446	0.001			0.054	0.003
	Total	0.346	447				0.038	0.001
firstAttackTime Gammatone3	Between groups	0.001	1	0.001	3.121	0.078	0.273	0.074
	Within groups	0.178	446	0.000			0.000	0.000
	Total	0.179	447				0.045	0.002
firstAttackTime Gammatone4	Between groups	0.002	1	0.002	3.238	0.073	0.013	0.000
	Within groups	0.292	446	0.001			0.154	0.024
	Total	0.294	447				0.438	0.192
firstAttackTime Gammatone5	Between groups	0.001	1	0.001	1.373	0.242	0.153	0.023
	Within groups	0.443	446	0.001			0.012	0.000
	Total	0.445	447				0.191	0.037
firstAttackTime Gammatone6	Between groups	0.000	1	0.000	0.002	0.962	0.252	0.063
	Within groups	0.305	446	0.001			0.064	0.004
	Total	0.305	447				0.043	0.002
firstAttackTime Gammatone7	Between groups	0.003	1	0.003	2.146	0.144	0.065	0.004
	Within groups	0.532	446	0.001			0.020	0.000
	Total	0.534	447				0.002	0.000
firstAttackTime Gammatone8	Between groups	0.000	1	0.000	0.085	0.771	0.040	0.002
	Within groups	0.551	446	0.001			0.064	0.004
	Total	0.551	447				0.076	0.006
firstAttackTime Gammatone9	Between groups	0.000	1	0.000	0.022	0.883	0.074	0.006
	Within groups	0.737	446	0.002			0.034	0.001
	Total	0.737	447				0.009	0.000
firstAttackTime Gammatone10	Between groups	0.016	1	0.016	9.723	0.002	0.058	0.003
	Within groups	0.728	446	0.002			0.067	0.005
	Total	0.744	447				0.437	0.191
harmonicEnergy	Between groups	0.000	1	0.000	0.018	0.892	0.093	0.009
	Within groups	2.473	446	0.006			0.073	0.005
	Total	2.473	447				0.033	0.001

		Sum of squares	df	Mean square	F	Sig.	η	η²
highestPeak Frequency	Between groups	439,393.269	1	439,393.269	6.457	0.011	0.044	0.002
	Within groups	30,349,183.684	446	68,047.497			0.007	0.000
	Total	30,788,576.953	447				0.059	0.003
inharmonicity	Between groups	0.005	1	0.005	0.683	0.409	0.063	0.004
	Within groups	3.386	432	0.008			0.122	0.015
	Total	3.392	433				0.046	0.002
lengthTrimmed	Between groups	10.725	1	10.725	0.231	0.631	0.118	0.014
	Within groups	20,744.377	446	46.512			0.041	0.002
	Total	20,755.102	447				0.034	0.001
loudnessSone	Between groups	7.181	1	7.181	0.073	0.787	0.002	0.000
	Within groups	43,991.223	446	98.635			0.123	0.015
	Total	43,998.404	447				0.059	0.003
lowEnergy	Between groups	0.003	1	0.003	0.082	0.775	0.042	0.002
	Within groups	18.094	446	0.041			0.012	0.000
	Total	18.097	447				0.050	0.003
maxRmsPosition	Between groups	1545.143	1	1545.143	0.359	0.549	0.015	0.000
	Within groups	1,918,465.286	446	4301.492			0.050	0.003
	Total	1,920,010.429	447				0.013	0.000
maxRmsValue	Between groups	0.006	1	0.006	0.657	0.418	0.109	0.012
	Within groups	4.407	446	0.010			0.110	0.012
	Total	4.413	447				0.049	0.002
melodiccontour-Comb	Between groups	537.830	1	537.830	2.802	0.095	0.177	0.031
	Within groups	85,599.894	446	191.928			0.109	0.012
	Total	86,137.724	447				0.066	0.004
mfcc1	Between groups	0.011	1	0.011	0.007	0.934	0.097	0.009
	Within groups	723.950	446	1.623			0.087	0.008
	Total	723.962	447				0.061	0.004
mfcc2	Between groups	0.066	1	0.066	0.658	0.418	0.010	0.000
	Within groups	44.565	446	0.100			0.084	0.007
	Total	44.631	447				0.008	0.000
mfcc3	Between groups	0.004	1	0.004	0.076	0.783	0.022	0.000
	Within groups	22.361	446	0.050			0.182	0.033
	Total	22.364	447				0.032	0.001
mfcc4	Between groups	0.562	1	0.562	29.547	0.000	0.002	0.000
	Within groups	8.484	446	0.019			0.042	0.002
	Total	9.046	447				0.027	0.001
mfcc5	Between groups	0.020	1	0.020	0.812	0.368	0.015	0.000
	Within groups	10.831	446	0.024			0.023	0.001
	Total	10.851	447				0.033	0.001

		Sum of squares	df	Mean square	F	Sig.	η	η^2
mfcc6	Between groups	0.041	1	0.041	0.830	0.363	0.138	0.019
	Within groups	21.784	446	0.049			0.007	0.000
	Total	21.824	447				0.050	0.003
mfcc7	Between groups	0.000	1	0.000	0.000	0.983	0.054	0.003
	Within groups	15.283	446	0.034			0.038	0.001
	Total	15.283	447				0.273	0.074
mfcc8	Between groups	0.276	1	0.276	13.808	0.000	0.000	0.000
	Within groups	8.899	446	0.020			0.045	0.002
	Total	9.175	447				0.013	0.000
mfcc9	Between groups	2.858	1	2.858	116.376	0.000	0.154	0.024
	Within groups	10.951	446	0.025			0.438	0.192
	Total	13.809	447				0.153	0.023
mfcc10	Between groups	0.802	1	0.802	12.922	0.000	0.012	0.000
	Within groups	27.693	446	0.062			0.191	0.037
	Total	28.495	447				0.252	0.063
mfcc11	Between groups	0.008	1	0.008	0.136	0.713	0.064	0.004
	Within groups	26.213	446	0.059			0.043	0.002
	Total	26.221	447				0.065	0.004
mfcc12	Between groups	0.081	1	0.081	16.084	0.000	0.020	0.000
	Within groups	2.254	446	0.005			0.002	0.000
	Total	2.335	447				0.040	0.002
mfcc13	Between groups	0.159	1	0.159	35.726	0.000	0.064	0.004
	Within groups	1.991	446	0.004			0.076	0.006
	Total	2.151	447				0.074	0.006
percussiveEnergy	Between groups	0.000	1	0.000	0.060	0.806	0.034	0.001
	Within groups	0.310	446	0.001			0.009	0.000
	Total	0.310	447				0.058	0.003
releaseTime	Between groups	0.006	1	0.006	0.592	0.442	0.067	0.005
	Within groups	4.753	446	0.011			0.437	0.191
	Total	4.759	447				0.093	0.009
releaseTime Gammatone1	Between groups	0.004	1	0.004	1.770	0.184	0.073	0.005
	Within groups	0.946	446	0.002			0.033	0.001
	Total	0.950	447				0.044	0.002
releaseTime Gammatone2	Between groups	0.001	1	0.001	0.149	0.699	0.007	0.000
	Within groups	2.428	446	0.005			0.059	0.003
	Total	2.429	447				0.063	0.004
releaseTime Gammatone3	Between groups	0.000	1	0.000	0.001	0.975	0.122	0.015
	Within groups	4.052	446	0.009			0.046	0.002
	Total	4.052	447				0.118	0.014

		Sum of squares	df	Mean square	F	Sig.	η	η^2
releaseTime Gammatone4	Between groups	0.003	1	0.003	1.057	0.305	0.041	0.002
	Within groups	1.268	446	0.003			0.034	0.001
	Total	1.271	447				0.002	0.000
releaseTime Gammatone5	Between groups	0.010	1	0.010	1.513	0.219	0.123	0.015
	Within groups	2.802	446	0.006			0.059	0.003
	Total	2.812	447				0.042	0.002
releaseTime Gammatone6	Between groups	0.006	1	0.006	2.002	0.158	0.012	0.000
	Within groups	1.448	446	0.003			0.050	0.003
	Total	1.454	447				0.015	0.000
releaseTime Gammatone7	Between groups	0.010	1	0.010	1.957	0.163	0.050	0.003
	Within groups	2.328	446	0.005			0.013	0.000
	Total	2.338	447				0.109	0.012
releaseTime Gammatone8	Between groups	0.001	1	0.001	0.280	0.597	0.110	0.012
	Within groups	1.067	446	0.002			0.049	0.002
	Total	1.068	447				0.177	0.031
releaseTime Gammatone9	Between groups	0.000	1	0.000	0.000	0.994	0.109	0.012
	Within groups	2.160	446	0.005			0.066	0.004
	Total	2.160	447				0.097	0.009
releaseTime Gammatone10	Between groups	0.009	1	0.009	1229	0.268	0.087	0.008
	Within groups	3.349	446	0.008			0.061	0.004
	Total	3.358	447				0.010	0.000
rms	Between groups	0.000	1	0.000	0.062	0.804	0.084	0.007
	Within groups	2.077	446	0.005			0.008	0.000
	Total	2.077	447				0.022	0.000
rmsGammatone1	Between groups	0.001	1	0.001	81.519	0.000	0.182	0.033
	Within groups	0.007	446	0.000			0.032	0.001
	Total	0.009	447				0.002	0.000
rmsGammatone2	Between groups	0.008	1	0.008	2.625	0.106	0.042	0.002
	Within groups	1.338	446	0.003			0.027	0.001
	Total	1.346	447				0.015	0.000
rmsGammatone3	Between groups	0.001	1	0.001	1.550	0.214	0.023	0.001
	Within groups	0.234	446	0.001			0.033	0.001
	Total	0.235	447				0.138	0.019
rmsGammatone4	Between groups	0.000	1	0.000	0.548	0.460	0.007	0.000
	Within groups	0.045	446	0.000			0.050	0.003
	Total	0.045	447				0.054	0.003
rmsGammatone5	Between groups	0.000	1	0.000	1.504	0.221	0.038	0.001
	Within groups	0.019	446	0.000			0.273	0.074
	Total	0.019	447				0.000	0.000

		Sum of squares	df	Mean square	F	Sig.	η	$η^2$
rmsGammatone6	Between groups	0.000	1	0.000	0.091	0.763	0.045	0.002
	Within groups	0.108	446	0.000			0.013	0.000
	Total	0.108	447				0.154	0.024
rmsGammatone7	Between groups	0.000	1	0.000	0.007	0.935	0.438	0.192
	Within groups	0.091	446	0.000			0.153	0.023
	Total	0.091	447				0.012	0.000
rmsGammatone8	Between groups	0.000	1	0.000	0.020	0.886	0.191	0.037
	Within groups	0.010	446	0.000			0.252	0.063
	Total	0.010	447				0.064	0.004
rmsGammatone9	Between groups	0.000	1	0.000	0.001	0.974	0.043	0.002
	Within groups	0.001	446	0.000			0.065	0.004
	Total	0.001	447				0.020	0.000
rmsGammatone10	Between groups	0.000	1	0.000	4.944	0.027	0.002	0.000
	Within groups	0.000	446	0.000			0.040	0.002
	Total	0.000	447				0.064	0.004
roughness	Between groups	352,774.584	1	352,774.584	0.032	0.859	0.076	0.006
	Within groups	4,977,814,805.234	446	11,161,019.743			0.074	0.006
	Total	4,978,167,579.818	447				0.034	0.001
spectralCentroid	Between groups	32,156.124	1	32,156.124	0.065	0.799	0.009	0.000
	Within groups	221,948,928.942	446	497,643.338			0.058	0.003
	Total	221,981,085.067	447				0.067	0.005
spectralFlatness	Between groups	0.000	1	0.000	0.465	0.496	0.437	0.191
	Within groups	0.163	446	0.000			0.093	0.009
	Total	0.163	447				0.073	0.005
spectralFluxMedian	Between groups	265.864	1	265.864	0.083	0.773	0.033	0.001
	Within groups	1,428,478.830	446	3202.867			0.044	0.002
	Total	1,428,744.694	447				0.007	0.000
spectralKurtosis	Between groups	2096.885	1	2096.885	3.693	0.055	0.059	0.003
	Within groups	253,251.891	446	567.829			0.063	0.004
	Total	255,348.776	447				0.122	0.015
spectralRolloff	Between groups	99,476.893	1	99,476.893	0.093	0.760	0.046	0.002
	Within groups	476,201,002.512	446	1,067,715.252			0.118	0.014
	Total	476,300,479.405	447				0.041	0.002
tonalEnergy	Between groups	0.005	1	0.005	0.683	0.409	0.034	0.001
	Within groups	3.386	432	0.008			0.002	0.000
	Total	3.392	433				0.123	0.015
zeroCrossingRate	Between groups	5112.653	1	5112.653	0.010	0.920	0.059	0.003
	Within groups	223,163,913.574	446	500,367.519			0.042	0.002
	Total	223,169,026.227	447				0.012	0.000

ANOVA table of distorted guitar sounds

		Sum of squares	df	Mean square	F	Sig.	η	η²
brightness	Between groups	0.006	1	0.006	0.294	0.588	0.008	0.000
	Within groups	8.824	446	0.020			0.041	0.002
	Total	8.830	447				0.042	0.002
entropy	Between groups	0.001	1	0.001	0.619	0.432	0.023	0.001
	Within groups	0.930	446	0.002			0.040	0.002
	Total	0.931	447				0.143	0.021
envelopeFlatness	Between groups	0.072	1	0.072	0.845	0.358	0.019	0.000
	Within groups	37.782	446	0.085			0.139	0.019
	Total	37.853	447				0.092	0.008
envelopeKurtosis	Between groups	4.466	1	4.466	0.073	0.787	0.186	0.035
	Within groups	27,175.409	446	60.931			0.119	0.014
	Total	27,179.875	447				0.113	0.013
envelopeQuantile Range	Between groups	0.003	1	0.003	0.233	0.630	0.133	0.018
	Within groups	5.033	446	0.011			0.133	0.018
	Total	5.035	447				0.204	0.042
firstAttackLeap	Between groups	0.504	1	0.504	9.536	0.002	0.087	0.008
	Within groups	23.584	446	0.053			0.075	0.006
	Total	24.088	447				0.163	0.027
firstAttackSlope	Between groups	112.445	1	112.445	0.671	0.413	0.002	0.000
	Within groups	74,727.682	446	167.551			0.022	0.000
	Total	74,840.127	447				0.061	0.004
firstAttackTime	Between groups	0.006	1	0.006	7.606	0.006	0.018	0.000
	Within groups	0.367	446	0.001			0.027	0.001
	Total	0.373	447				0.065	0.004
firstAttackTime Gammatone1	Between groups	0.002	1	0.002	2.481	0.116	0.030	0.001
	Within groups	0.336	446	0.001			0.034	0.001
	Total	0.338	447				0.095	0.009
firstAttackTime Gammatone2	Between groups	0.011	1	0.011	12.981	0.000	0.016	0.000
	Within groups	0.378	446	0.001			0.299	0.090
	Total	0.389	447				0.283	0.080
firstAttackTime Gammatone3	Between groups	0.002	1	0.002	3.591	0.059	0.494	0.244
	Within groups	0.233	446	0.001			0.014	0.000
	Total	0.235	447				0.100	0.010
firstAttackTime Gammatone4	Between groups	0.001	1	0.001	1.741	0.188	0.012	0.000
	Within groups	0.209	446	0.000			0.149	0.022
	Total	0.210	447				0.568	0.322
firstAttackTime Gammatone5	Between groups	0.001	1	0.001	2.565	0.110	0.218	0.047
	Within groups	0.187	446	0.000			0.026	0.001
	Total	0.188	447				0.019	0.000

		Sum of squares	df	Mean square	F	Sig.	η	η²
firstAttackTime Gammatone6	Between groups	0.002	1	0.002	4.475	0.035	0.518	0.268
	Within groups	0.192	446	0.000			0.059	0.003
	Total	0.194	447				0.063	0.004
firstAttackTime Gammatone7	Between groups	0.005	1	0.005	10.154	0.002	0.108	0.012
	Within groups	0.207	446	0.000			0.076	0.006
	Total	0.212	447				0.022	0.000
firstAttackTime Gammatone8	Between groups	0.001	1	0.001	1.725	0.190	0.052	0.003
	Within groups	0.213	446	0.000			0.119	0.014
	Total	0.214	447				0.126	0.016
firstAttackTime Gammatone9	Between groups	0.001	1	0.001	1.188	0.276	0.073	0.005
	Within groups	0.385	446	0.001			0.047	0.002
	Total	0.386	447				0.019	0.000
firstAttackTime Gammatone10	Between groups	0.011	1	0.011	9.382	0.002	0.090	0.008
	Within groups	0.500	446	0.001			0.012	0.000
	Total	0.510	447				0.445	0.198
harmonicEnergy	Between groups	0.000	1	0.000	0.045	0.832	0.067	0.004
	Within groups	4.731	446	0.011			0.049	0.002
	Total	4.731	447				0.043	0.002
highestPeakFre-quency	Between groups	349,447.936	1	349,447.936	5.166	0.024	0.082	0.007
	Within groups	30,166,372.991	446	67,637.608			0.032	0.001
	Total	30,515,820.926	447				0.116	0.013
inharmonicity	Between groups	0.011	1	0.011	1.334	0.249	0.124	0.015
	Within groups	3.433	428	0.008			0.209	0.044
	Total	3.443	429				0.016	0.000
lengthTrimmed	Between groups	5.098	1	5.098	0.094	0.759	0.084	0.007
	Within groups	24,167.475	446	54.187			0.041	0.002
	Total	24,172.573	447				0.333	0.111
loudnessSone	Between groups	1.585	1	1.585	0.017	0.895	0.017	0.000
	Within groups	40,883.916	446	91.668			0.289	0.084
	Total	40,885,501	447				0.039	0.002
lowEnergy	Between groups	0.028	1	0.028	0.665	0.415	0.060	0.004
	Within groups	18.793	446	0.042			0.119	0.014
	Total	18.821	447				0.008	0.000
maxRmsPosition	Between groups	7361.286	1	7361.286	0.333	0.564	0.041	0.002
	Within groups	9,862,433.705	446	22,113.080			0.042	0.002
	Total	9,869,794.991	447				0.023	0.001
maxRmsValue	Between groups	0.000	1	0.000	0.014	0.906	0.040	0.002
	Within groups	4.603	446	0.010			0.143	0.021
	Total	4.604	447				0.019	0.000

		Sum of squares	df	Mean square	F	Sig.	η	η²
melodiccontour Comb	Between groups	37.853	1	37.853	0.606	0.437	0.139	0.019
	Within groups	27,852.325	446	62.449			0.092	0.008
	Total	27,890.178	447				0.186	0.035
mfcc1	Between groups	0.131	1	0.131	0.184	0.668	0.119	0.014
	Within groups	318.018	446	0.713			0.113	0.013
	Total	318.149	447				0.133	0.018
mfcc2	Between groups	1.070	1	1.070	13.112	0.000	0.133	0.018
	Within groups	36.386	446	0.082			0.204	0.042
	Total	37.456	447				0.087	0.008
mfcc3	Between groups	1.235	1	1.235	31.363	0.000	0.075	0.006
	Within groups	17.565	446	0.039			0.163	0.027
	Total	18.800	447				0.002	0.000
mfcc4	Between groups	2.475	1	2.475	118.612	0.000	0.022	0.000
	Within groups	9.306	446	0.021			0.061	0.004
	Total	11.781	447				0.018	0.000
mfcc5	Between groups	0.008	1	0.008	0.460	0.498	0.027	0.001
	Within groups	7.850	446	0.018			0.065	0.004
	Total	7.858	447				0.030	0.001
mfcc6	Between groups	0.279	1	0.279	6.198	0.013	0.034	0.001
	Within groups	20.082	446	0.045			0.095	0.009
	Total	20.361	447				0.016	0.000
mfcc7	Between groups	0.000	1	0.000	0.001	0.978	0.299	0.090
	Within groups	12.554	446	0.028			0.283	0.080
	Total	12.554	447				0.494	0.244
mfcc8	Between groups	0.226	1	0.226	16.506	0.000	0.014	0.000
	Within groups	6.095	446	0.014			0.100	0.010
	Total	6.321	447				0.012	0.000
mfcc9	Between groups	3.187	1	3.187	203.625	0.000	0.149	0.022
	Within groups	6.981	446	0.016			0.568	0.322
	Total	10.169	447				0.218	0.047
mfcc10	Between groups	0.968	1	0.968	28.408	0.000	0.026	0.001
	Within groups	15.195	446	0.034			0.019	0.000
	Total	16.163	447				0.518	0.268
mfcc11	Between groups	0.039	1	0.039	0.684	0.408	0.059	0.003
	Within groups	25.536	446	0.057			0.063	0.004
	Total	25.575	447				0.108	0.012
mfcc12	Between groups	0.012	1	0.012	2.972	0.085	0.076	0.006
	Within groups	1.762	446	0.004			0.022	0.000
	Total	1.774	447				0.052	0.003

		Sum of squares	df	Mean square	F	Sig.	η	η^2
mfcc13	Between groups	0.521	1	0.521	138.615	0.000	0.119	0.014
	Within groups	1.676	446	0.004			0.126	0.016
	Total	2.197	447				0.073	0.005
percussiveEnergy	Between groups	0.000	1	0.000	0.229	0.632	0.047	0.002
	Within groups	0.339	446	0.001			0.019	0.000
	Total	0.339	447				0.090	0.008
releaseTime	Between groups	0.005	1	0.005	1.226	0.269	0.012	0.000
	Within groups	1.815	446	0.004			0.445	0.198
	Total	1.819	447				0.067	0.004
releaseTime Gammatone1	Between groups	0.007	1	0.007	5.249	0.022	0.049	0.002
	Within groups	0.607	446	0.001			0.043	0.002
	Total	0.614	447				0.082	0.007
releaseTime Gammatone2	Between groups	0.015	1	0.015	2.985	0.085	0.032	0.001
	Within groups	2.199	446	0.005			0.116	0.013
	Total	2.214	447				0.124	0.015
releaseTime Gammatone3	Between groups	0.003	1	0.003	0.265	0.607	0.209	0.044
	Within groups	4.360	446	0.010			0.016	0.000
	Total	4.363	447				0.084	0.007
releaseTime Gammatone4	Between groups	0.002	1	0.002	0.846	0.358	0.041	0.002
	Within groups	0.905	446	0.002			0.333	0.111
	Total	0.906	447				0.017	0.000
releaseTime Gammatone5	Between groups	0.012	1	0.012	5.157	0.024	0.289	0.084
	Within groups	1.075	446	0.002			0.039	0.002
	Total	1.088	447				0.060	0.004
releaseTime Gammatone6	Between groups	0.010	1	0.010	6.858	0.009	0.119	0.014
	Within groups	0.676	446	0.002			0.008	0.000
	Total	0.686	447				0.041	0.002
releaseTime Gammatone7	Between groups	0.004	1	0.004	1.892	0.170	0.042	0.002
	Within groups	0.893	446	0.002			0.023	0.001
	Total	0.896	447				0.040	0.002
releaseTime Gammatone8	Between groups	0.001	1	0.001	0.914	0.340	0.143	0.021
	Within groups	0.699	446	0.002			0.019	0.000
	Total	0.701	447				0.139	0.019
releaseTime Gammatone9	Between groups	0.001	1	0.001	0.200	0.655	0.092	0.008
	Within groups	1.143	446	0.003			0.186	0.035
	Total	1.143	447				0.119	0.014
releaseTime Gammatone10	Between groups	0.008	1	0.008	2.900	0.089	0.113	0.013
	Within groups	1.300	446	0.003			0.133	0.018
	Total	1.308	447				0.133	0.018

		Sum of squares	df	Mean square	F	Sig.	η	η²
rms	Between groups	0.005	1	0.005	0.645	0.422	0.204	0.042
	Within groups	3.297	446	0.007			0.087	0.008
	Total	3.302	447				0.075	0.006
rmsGammatone1	Between groups	0.002	1	0.002	88.009	0.000	0.163	0.027
	Within groups	0.012	446	0.000			0.002	0.000
	Total	0.014	447				0.022	0.000
rmsGammatone2	Between groups	0.009	1	0.009	1.437	0.231	0.061	0.004
	Within groups	2.913	446	0.007			0.018	0.000
	Total	2.923	447				0.027	0.001
rmsGammatone3	Between groups	0.001	1	0.001	0.802	0.371	0.065	0.004
	Within groups	0.460	446	0.001			0.030	0.001
	Total	0.461	447				0.034	0.001
rmsGammatone4	Between groups	0.000	1	0.000	0.754	0.386	0.095	0.009
	Within groups	0.053	446	0.000			0.016	0.000
	Total	0.053	447				0.299	0.090
rmsGammatone5	Between groups	0.000	1	0.000	1.801	0.180	0.283	0.080
	Within groups	0.026	446	0.000			0.494	0.244
	Total	0.027	447				0.014	0.000
rmsGammatone6	Between groups	0.000	1	0.000	0.025	0.873	0.100	0.010
	Within groups	0.124	446	0.000			0.012	0.000
	Total	0.124	447				0.149	0.022
rmsGammatone7	Between groups	0.000	1	0.000	0.121	0.728	0.568	0.322
	Within groups	0.063	446	0.000			0.218	0.047
	Total	0.063	447				0.026	0.001
rmsGammatone8	Between groups	0.000	1	0.000	0.022	0.883	0.019	0.000
	Within groups	0.004	446	0.000			0.518	0.268
	Total	0.004	447				0.059	0.003
rmsGammatone9	Between groups	0.000	1	0.000	0.123	0.726	0.063	0.004
	Within groups	0.000	446	0.000			0.108	0.012
	Total	0.000	447				0.076	0.006
rmsGammatone10	Between groups	0.000	1	0.000	0.281	0.596	0.022	0.000
	Within groups	0.000	446	0.000			0.052	0.003
	Total	0.000	447				0.119	0.014
roughness	Between groups	23,929.839	1	23,929.839	0.003	0.960	0.126	0.016
	Within groups	4,188,914,488.722	446	9,392,184.952			0.073	0.005
	Total	4,188,938,418.560	447				0.047	0.002
spectralCentroid	Between groups	142,963.034	1	142,963.034	0.607	0.436	0.019	0.000
	Within groups	104,979,838.328	446	235,380.803			0.090	0.008
	Total	105,122,801.362	447				0.012	0.000

		Sum of squares	df	Mean square	F	Sig.	η	η^2
spectralFlatness	Between groups	0.004	1	0.004	44.972	0.000	0.445	0.198
	Within groups	0.043	446	0.000			0.067	0.004
	Total	0.047	447				0.049	0.002
spectralFluxMedian	Between groups	3.494	1	3.494	0.001	0.977	0.043	0.002
	Within groups	1,869,200.980	446	4,191.034			0.082	0.007
	Total	1,869,204.474	447				0.032	0.001
spectralKurtosis	Between groups	3431.394	1	3431.394	38.791	0.000	0.116	0.013
	Within groups	39,452.603	446	88.459			0.124	0.015
	Total	42,883.997	447				0.209	0.044
spectralRolloff	Between groups	91,146.110	1	91,146.110	0.190	0.663	0.016	0.000
	Within groups	213,518,567.950	446	478,741.184			0.084	0.007
	Total	213,609,714.060	447				0.041	0.002
tonalEnergy	Between groups	0.010	1	0.010	1.281	0.258	0.333	0.111
	Within groups	3.434	428	0.008			0.017	0.000
	Total	3.444	429				0.289	0.084
zeroCrossingRate	Between groups	792,049.376	1	792,049.376	2.309	0.129	0.039	0.002
	Within groups	153,006,170.836	446	343,063.163			0.060	0.004
	Total	153,798,220.212	447				0.119	0.014

REFERENCE

Cohen, J. (1988), *Statistical Power Analysis for the Behavioral Sciences*, Hillsdale, MI: Lawrence Erlbaum.