

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

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 skeptical 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 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 democratisation 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 digitalisation that allows recording many instruments on separate tracks and mixing multiple layers of guitar (Mynett 2012, 2017; Herbst 2017). In addition, the options for optimising 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 guitarⁱ, 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 the guitar's sound control have greatly expanded with 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: 151ff). 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: 297ff). Seymour Duncan and Dimarzio, for instance, created a profitable product line with exact replicas of pickups from the 1950s, '60s and '70s. Equally successful are Fender and Gibson with reissues of their former guitar models (Herbst 2016: 84ff; Uimonen 2016: 5). A similar development occurred with innovations in amplification technology. The electric guitar was initially played with valve amplifiers like the Fender Bassman not specifically designed for the guitar

(Bacon 1996: 14f). 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 equalisation options and additional resonance and presence controls were introduced in the 1960s and '70s to improve the options of adjusting the sound (Herbst 2016: 36). These early amplifiers are still popular today, and many modern devices are contemporary derivations with greater gain capabilities through an additional pre-amplifier section (Brosnac 1987; Herbst 2016: 297ff). 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" (Malooof 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 (Malooof 2004: 209ff). Newer models, the JVM series for instance, are characterised by a greater functionality due to its higher number of channels. Marshall 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" (Marshall 2017).

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 little 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 gain greater 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: 26ff). 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: 99ff). 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: 297ff).

Digitalisation found its way into guitar technology in 1989 when Tech 21 released the SansAmp, an analogue valve amplifier emulator which 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 the casual playing at home. Both the VG-8 and the POD, like many of its successors, are based on a technology that digitises 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 modelers) 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 simulations in a plugin format to be inserted in digital audio workstations emerged in the early 2000s and were well received for tracking demo performances, but were rarely considered a serious alternative to recording valve amplifiers.ⁱⁱ 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).

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: 18f) 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 social 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-standardised 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 of metal guitar players and music producers in the quality of the profiling technology. This hardly is 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 specialised and expensive valve amplifiers would dwindle, ultimately leading to a democratisation 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 are aiming at promoting 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 synthesisers 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 were limited to 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 20 seconds is used to analyse the amplifier’s response. The official Kemper Profiling Guide (2016: 8) 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.”

Audio Example 1ⁱⁱⁱ 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 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 Luetzge Signature Rig Pack” are distributed for free. In case that the profiling has been done properly, as can be expected from licensed profiles, Kemper 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” (Kemper 2017a).

The second purpose of the device is to virtually copy and optimise 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 tweaking 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 consisted of 24 reviews and 35 threads in the forums: GearsLutz.com, Homerecording.com, KVRAudio.com, SoundonSound.com, Studio-Central.com, Ultimate-metal.com and Kemper-Amps.com. Most threads comprised of several pages, maximum 56 pages with 1,119 posts in the Ultimate Metal board. The forums were chosen because they represented a mixture of discussions among guitar players and music producers. Categories have been extracted with a qualitative content analysis approach (Cresswell 2003: 190ff).

Reviews

In all reviews, the tradition-consciousness and tendency to favour analogue vintage amplifiers was 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 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 like recording drums 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."^{iv}

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"^v. 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 on stage 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."^{vi}

The line between home recording and professional production thus becomes blurry. Yet, there also was critique on the sound quality. Some criticised the clean sounds, especially regarding the articulation and dynamics. Most criticism, however, concerned the distorted sound and differences in specific 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 10 kHz 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"^{vii}. Due to this common problem, users compared auditory impressions and analysed the signals in digital audio workstations.^{viii} 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.

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". 16 different valve amplifiers (see Table 7 in the Appendix) were tested. All amplifiers were recorded at 115 dB in a professional recording studio with a Shure SM57 dynamic microphone in front of a Marshall 1960AV cabinet with Celestion Vintage 30

speakers. 14 stimuli were recorded in Logic X with a MOTU 424 PCI audio card. These stimuli were re-amped later using the 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 6th 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 (62 Hz) 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 20 seconds 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, 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 115 dB in which cases the output was reduced. All recordings were normalised to -0.1 dBFS in the audio export to make up for these peak volume differences. The final data consisted of 1,344 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 in detail. The data of this study was created with an audio-based feature extraction using the MIR (Lartillot and Toivainen 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 0.05 seconds. Consequently, measures describing the spectral shape of a sound (e.g. the central areas of the spectrum) and its temporal evolution 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.^{ix} 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 standardised units such as dB or Hz (Table 8), others had numeric values resulting from algorithmic calculations standardised 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 visualise 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, Depalle and Clarke 2004: 167), providing a more holistic picture than single acoustic features do.

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 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.

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

Descriptor	MFCC 9	MFCC 4	RMS Gammatone 1	MFCC 10	MFCC 13
Effect	.237***	.096***	.088***	.050***	.043***
Descriptor	MFCC 8	First Attack Time Gammatone 10	Release Time Gammatone 8	Spectral Flatness	MFCC 12
Effect	.037***	.024***	.024***	.023***	.022***

Note: *** $p < .001$; $N = 1,152$.

The biggest differences occurred in the mel-frequency cepstral coefficients (MFCC) that capture timbral properties by parametrising the rough shape of the spectral envelope (Müller 2015: 177) with closer approximation to the nonlinear human hearing than the linear frequency scale does (Lartillot 2014: 129). This result indicates audible divergences 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 in detail 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 there. 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 with weak to medium effects. Profiles and sounds interacted regarding RMS^x Gammatone 1 ($\eta^2 = .091$; $p < .001$) whilst profiles and amplifier models did so concerning MFCC 4 ($\eta^2 = .057$; $p < .001$).

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 indicating that the profiles are quieter.

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

Descriptor	MFCC 9	Release Time Gammatone 8	MFCC 10	Maximum RMS Value	RMS Gammatone 5
Effect	.231***	.107***	.102***	.100***	.076***
Descriptor	MFCC 4	Loudness (Sone)	MFCC 8	RMS	Percussive Energy
Effect	.074***	.071***	.069***	.060***	.050***

Note: *** $p < .001$; $N = 384$.

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 to a very strong effect with the profiles having higher values, complying with the 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.

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

Descriptor	MFCC 9	RMS Gamma-tone 1	MFCC 4	MFCC 13	MFCC 12
Effect	.192***	.191***	.074***	.063***	.037***
Descriptor	First Attack Time Gammatone 10	First Attack Leap	MFCC 8	MFCC 10	Maximum RMS Value
Effect	.033***	.031***	.024**	.023**	.019**

Note: *** $p < .001$, ** $p < .01$; $N = 384$.

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

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

Descriptor	MFCC 9	MFCC 13	MFCC 4	RMS Gamma-tone 1	Spectral Flatness
Effect	.322***	.268***	.244***	.198***	.111***
Descriptor	MFCC 2	Spectral Kurtosis	MFCC 3	RMS Gamma-tone 9	MFCC 10
Effect	.090***	.084***	.080***	.044***	.047***

Note: *** $p < .001$; $N = 384$.

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.

Table 5. Differences between original and profile for different stimuli

	All guitars	Clean guitars	Overdriven guitars	Distorted guitars	White noise	Needle pulse
Cumulated eta square	.783	1.603	.895	1.923	4.504	6.798
Mean eta square	.011	.023	.013	.027	.063	.096
Unweighted significances	25	31	16	26	23	43

<i>Weighted significances</i>	6.2	11.8	7.6	7.8	8.4	19.5
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Note: 71 unweighted significances and 32.6 weighted significances were the maximum.

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: 16f) highlights the importance of playing for the refinement but since the same performance was used, this variable is ruled out.

Table 6. Differences between original and profile for amplifier models

	<i>Bogner</i>	<i>Earforce</i>	<i>Engl</i>	<i>Fender Super</i>	<i>Fender Twin</i>	<i>Fryette</i>	<i>Laney</i>	<i>Marshall 1987</i>
<i>Cumulated eta square</i>	.858	.502	1.117	1.174	.873	1.544	1.521	.902
<i>Mean eta square</i>	.012	.007	.016	.017	.012	.022	.021	.013
<i>Unweighted significances</i>	4	2	5	4	3	11	6	2
<i>Weighted significances</i>	.7	.4	.9	1.4	.5	3.5	1.9	.3
	<i>Marshall JCM</i>	<i>Triaxis 2:20</i>	<i>Triaxis 5150</i>	<i>Orange</i>	<i>Peavey</i>	<i>Real Guitars</i>	<i>Splawn</i>	<i>Vox</i>
<i>Cumulated eta square</i>	1.346	3.064	1.277	1.450	1.397	1.905	.954	.797
<i>Mean eta square</i>	.019	.043	.018	.020	.020	.027	.013	.011
<i>Unweighted significances</i>	7	14	8	6	8	10	5	4
<i>Weighted significances</i>	2.7	4.7	2.1	1.9	2.2	1.5	.8	1.5

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

Summing up, the quality of the profiles was generally very good with a low average of 6 out of 71 (8%) unweighted and 1.7 out of 32.6 (5%) 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 for a final conclusion on the profiles' quality.

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 in profile than clean sounds and because profiling, according to the official Profiling Guide (2016: 8f), 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 in both recordings reached the 23rd integer (approx. 14.5 kHz), the upper partials over the primary frequency range of the speaker above 5 kHz (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 20 kHz in the profiled sound not present in the original.^{xi} However, no significant differences could be perceived even when listening with a high-pass filter set at 15 kHz.

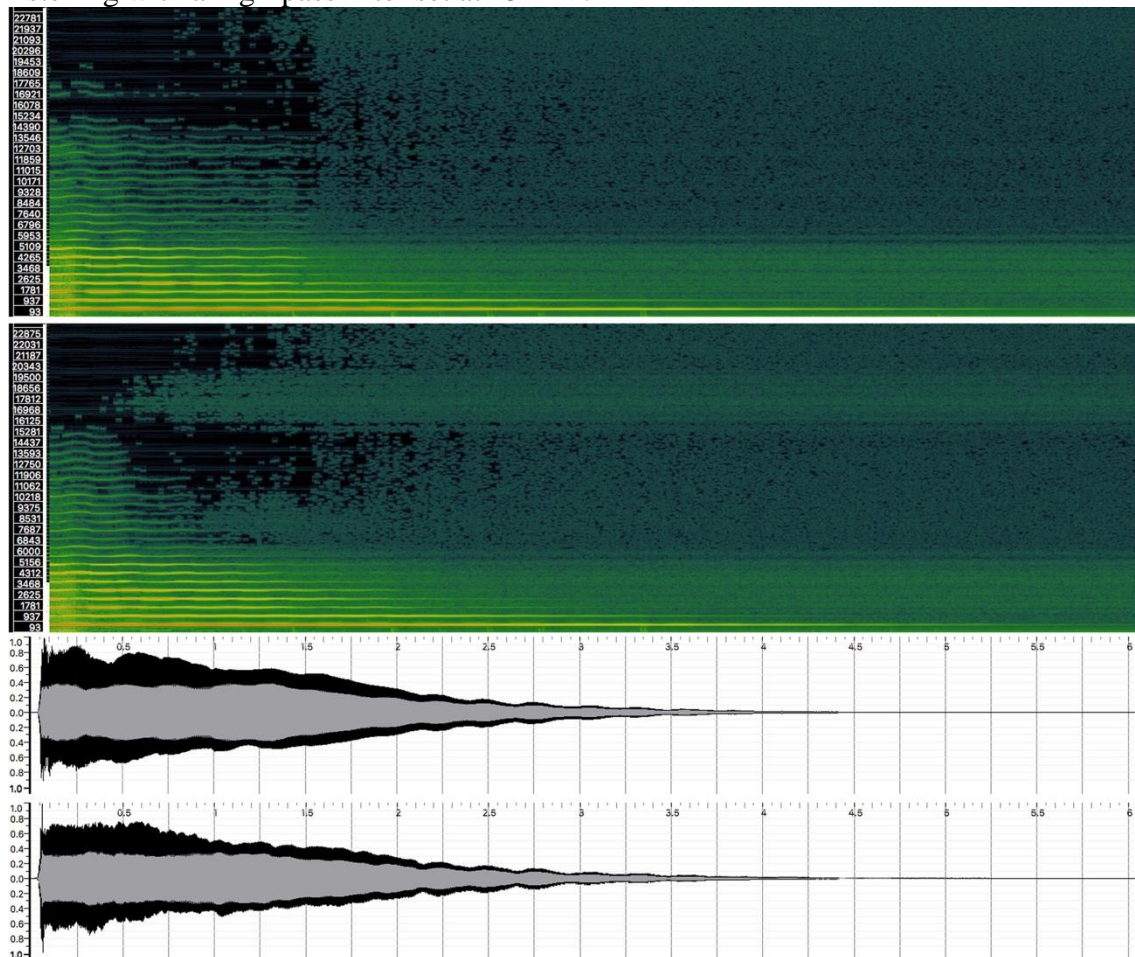


Figure 1: Spectrograms of a E5 (660 Hz) note with vibrato played with an overdriven Bogner Goldfinger amplifier; top: original; bottom: profile; 1024 window.

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 kHz and 6.5 kHz were replicated authentically. Only the overtones decayed faster in the profiled sound yet barely audibly.

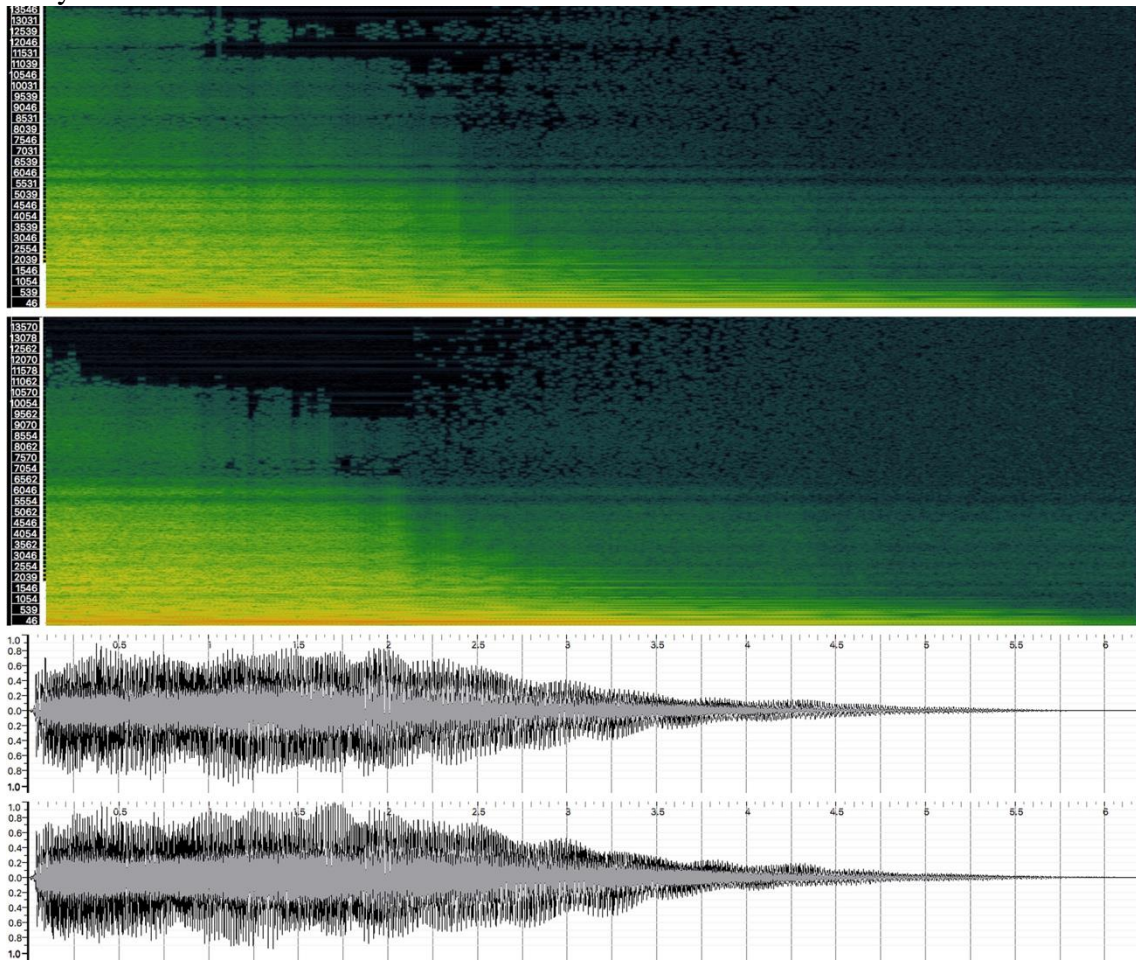


Figure 2: Spectrograms of D power chord in drop D tuning played with an overdriven Marshall 1987X amplifier; top: original; bottom: profile; 2048 window.

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

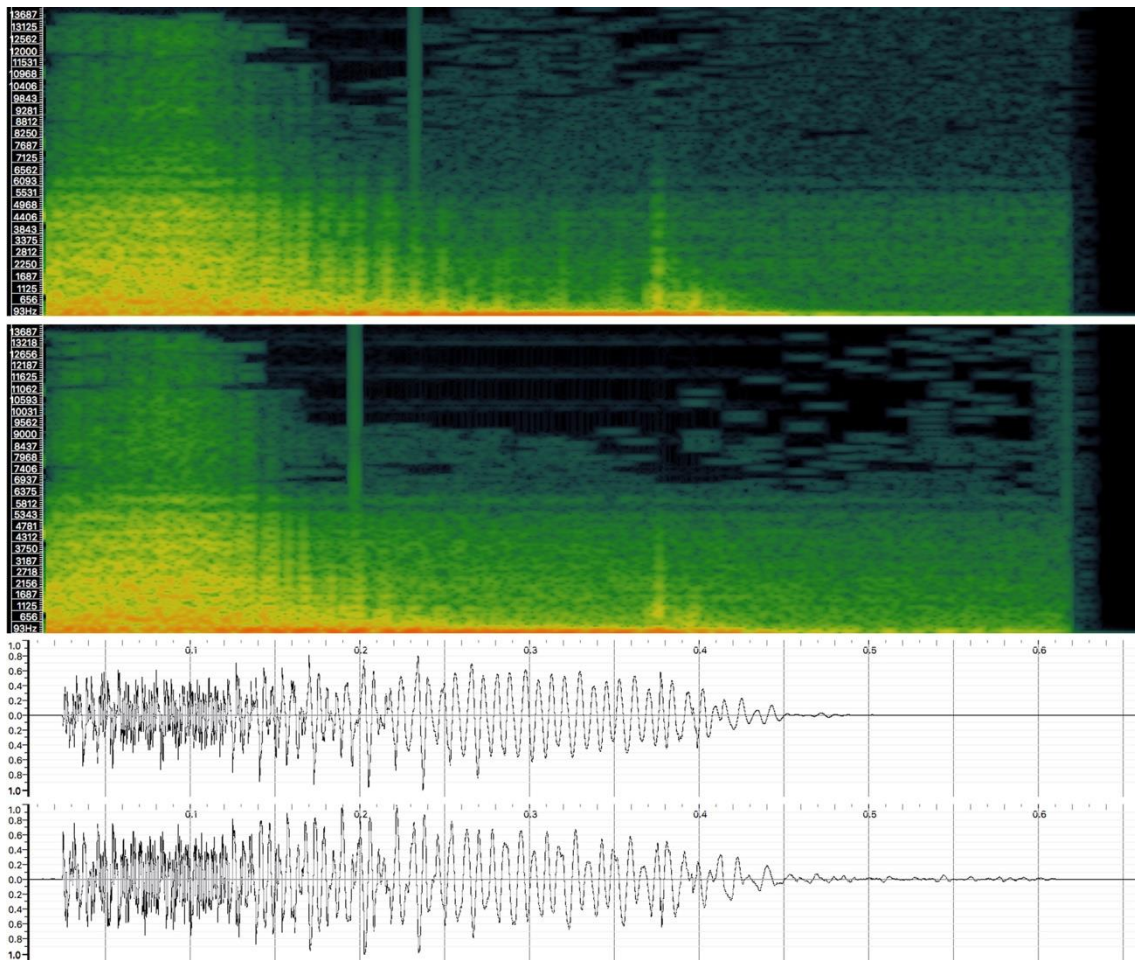


Figure 3: Spectrograms of a B1 (62 Hz) palm muted power chord played with an overdriven Peavey 5150 amplifier; top: original; bottom: profile; 2048 window.

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 watts' 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 sensible extension of the acoustic experiment. The playing feel was a further aspect not possible to explore 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 social and technological dimensions. As the qualitative findings have shown, many guitar players and producers were skeptical of 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 characterised by a nostalgic and tradition-conscious mind of many of its players. Even if metal guitar players according to a recent study (Herbst 2016: 297ff) show more openness towards newer technologies than guitarists of other genres do, the online boards and Sneap’s statement still indicate that 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 overall was very good. 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: 134ff), 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: 13:00f) 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.

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, Michael Wagener (2013: 7:00f) 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, digitalisation 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: 262ff) showed, competing with technical equipment is not popular among many professionals. Guitar profiling technology could diminish the need of 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), digitalisation 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 amplification. 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: 103f) would be valued more as there was no need to compete with equipment (Martin 2014: 262ff). However, technical service jobs such as re-amping, currently making up a considerable income source for many professional studios, will increasingly become obsolete.^{xii}

In the light of such prospects, Sneap (2012: 5:40) predicts profiling technology to “move recording forward the same way as Pro Tools has”^{xiii} and Wagener (2013: 6:40f) concludes it to be “the biggest innovation for recording at least for the last fifteen years”. But as Wagener (2013: 26:40f) 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.^{xiv} 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: 1:50f). 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 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.^{xv} Alternatively, just as drum computers have been used in metal music productions to simulate double bass 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.

Conclusion

Metal music research from the viewpoint of music technology and production has been claimed to be in an “embryonic phase” (Mynett 2013: 18f). 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 derivatives 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.

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References

- Anderton, C. (2013), ‘Expert review: Kemper Profiling Amp’, <http://www.harmonycentral.com/expert-reviews/kemper-profiling-amp>. Accessed 25 May 2017.
- Aurigemma, M. (2015), ‘Review: Kemper Profiling Amplifier’, *Sam Ash Music*, <http://spotlight.samash.com/review-kemper-profiling-amplifier>. Accessed 25 May 2017.
- Bacon, T. (1996), *Rock Hardware. The Instruments, Equipment and Technology of Rock*, Poole: Blandford Press.

- Beech, R. (2012), 'Review: Kemper Profiling Amp (Video)', *Sonic State Amped*, <http://www.sonicstate.com/amped/2012/10/15/review-kemper-profiling-amp>. Accessed 25 May 2017.
- Bennett, H. S. (1983), 'Notation and Identity in Contemporary Popular Music', *Popular Music*, 3, pp. 215-234.
- Berger, H. M. and Fales, C. (2005), "'Heaviness" in the Perception of Heavy Metal Guitar Timbres. The Match of Perceptual and Acoustic Features over Time', in P. D. Greene and T. Porcello (eds.), *Wired for sound. Engineering and technologies in sonic cultures*, Middletown, CT: Wesleyan University Press, pp. 181-197.
- Brend, M. (2012), *The Sound of Tomorrow. How Electronic Music was Smuggled into the Mainstream*, New York: Bloomsbury.
- Brosnac, D. (2004), *The Amp Book. A Guitarist's introductory Guide to Tube Amplifiers*, Westport: The Bold Strummer.
- Burns, J. (2016), 'The History and Future of Amp Modeling', <http://philoking.com/2016/01/28/the-history-and-future-of-amp-modeling>. Accessed 19 December 2017.
- Celestion (2017), 'Vintage 30', http://celestion.com/product/1/vintage_30. Accessed 25 May 2017.
- Chappell, J. (2010), *The Recording Guitarist. A Guide to Studio Gear, Techniques and Tone*, Milwaukee: Hal Leonard.
- Collins, S. (2011), 'Christoph Kemper of Kemper Amps Talks About Their New Profiling Amp. Guitar Muse', <http://www.guitar-muse.com/kemper-profiling-amp-2949-2949>. Accessed 25 May 2017.
- Cook, N. and Leech-Wilkinson, D. (2009), 'A musicologist's guide to Sonic Visualiser', http://www.charm.rhul.ac.uk/analysing/p9_1.html. Accessed 25 May 2017.
- Cresswell, J. W. (2003), *Research Design. Qualitative, Quantitative and Mixed Methods Approaches*, Thousand Oaks: Sage.
- Davodowich, D. (2015), 'Kemper Profiling Amplifier'. *Music Players.com*, http://musicplayers.com/reviews/guitars/2015/0115_Kemper.php. Accessed 25 May 2017.
- Doyle, M. (1993), *The Sound of Rock. A History of Marshall Valve Guitar Amplifiers*, Westport: The Bold Strummer.
- Driedger, J. and Müller, M. (2014), 'TSM Toolbox: MATLAB Implementations of Time-Scale Modification Algorithms', *Proceedings of the 17th International Conference on Digital Audio Effects*, Erlangen, 2017, http://www.dafx14.fau.de/papers/dafx14_jonathan_driedger_tsm_toolbox_matlab_imple.pdf. Accessed 25 May 2017.
- Dubnov, S. (2004), 'Generalization of Spectral Flatness Measure for Non-Gaussian Linear Processes', *Signal Processing Letters*, 11:8, pp. 698-701.
- Eichenberger, D. (2015), 'Giggin without an amp', <http://www.seymourduncan.com/blog/tips-and-tricks/gigging-without-an-amp>. Accessed 25 May 2017.
- Einbrodt, U. D. (1997), *Experimentelle Untersuchungen zum Gitarrensound in der Rockmusik [Experimental Studies on the Guitar Sound in Rock Music]*, Frankfurt am Main: Peter Lang.
- Genesis (2009), 'Loudness Toolbox', http://genesis-acoustics.com/en/loudness_online-32.html. Accessed 25 May 2017.
- Greeves, D. (2012), 'Kemper Profiling Amplifier', *Sound on Sound*, <http://www.soundonsound.com/reviews/kemper-profiling-amplifier>. Accessed 25 May 2017.
- Hamidovic, E. (2015), *The Systematic Mixing Guide*, Melbourne: Systematic Productions.

- Herbst, J.-P. (2016), *Die Gitarrenverzerrung in der Rockmusik [The guitar distortion in rock music]*, Muenster: Lit.
- Herbst, J.-P. (2017), 'Historical development, sound aesthetics and production techniques of the distorted electric guitar in metal music', *Metal Music Studies*, 3:1, pp. 24-46.
- Holmes, T. (2002), *Electronic and experimental music. Pioneers in technology and composition*, 2. ed., New York: Routledge.
- Jones, S. (1992), *Rock Formation. Music, Technology, and Mass Communication*, Thousand Oaks: Sage.
- Kealey, E. R. (1982), 'Conventions and the Production of the Popular Music Aesthetic', *Journal of Popular Culture*, 16:2, pp. 100-115.
- Kemper (2016), *Kemper Profiling Guide*, <https://www.kemper-amps.com/download/87/Profiling-Guide>. Accessed 25 May 2017.
- Kemper (2017a), 'The Kemper Profiler', <https://www.kemper-amps.com/profiler/overview>. Accessed 25 May 2017.
- Kemper (2017b), 'Rig exchange', <https://www.kemper-amps.com/rig/exchange>. Accessed 25 May 2017.
- Lartillot, O. (2014), *MIRtoolbox 1.6.1. User's manual*, <https://www.jyu.fi/hytk/fi/laitokset/mutku/en/research/materials/mirtoolbox/MIRtoolbox1.6.1guide>. Accessed 8 July 2017.
- Lartillot, O. and Toiviainen, P. (2007), 'A Matlab Toolbox for Musical Feature Extraction From Audio', *Proceedings of the 10th International Conference on Digital Audio Effects*, Bordeaux, 2007, <http://dafx.labri.fr/main/papers/p237.pdf>. Accessed 25 May 2017.
- Lemme, H. (1995), *Gitarren-Verstärker-Sound [Guitar amplifier sound]*, Muenchen: Pflaum Verlag.
- Leyshon, A. (2009), 'The Software Slump?: digital music, the democratisation of technology, and the decline of the recording studio sector within the musical economy', *Environment and Planning A*, 49, pp. 1309-1331.
- Maloof, R. (2004), *Jim Marshall. The Father of Loud*, San Francisco: Backbeat Books.
- Marshall (2017), 'JVM410H', <https://marshallamps.com/products/amplifiers/jvm4-series/jvm410h>. Accessed 25 May 2017.
- Martin, A. (2014), *The Role and Working Practice of Music Producers: An Interpretative Phenomenological Analysis*, PhD thesis, University of Hull.
- Martinelli, R. (2006), 'Interview: Andy Sneap', *Maelstrom*, 45, http://www.maelstromzine.com/ezone/interview_iss45_208.php. Accessed 25 May 2017.
- McAdams, S., P. Depalle and E. Clarke (2004), 'Analyzing Musical Sound', in E. Clarke and N. Cook (eds.), *Empirical Musicology. Aims. Methods. Prospects*, Oxford: Oxford University Press, pp. 157-196.
- McKenzie, T. (2017), 'Kemper Profiling Guitar Amplifier Review', <http://www.tonymckenzie.com/kemper-amps-review.htm>. Accessed 25 May 2017.
- Müller, M. (2015), *Fundamentals of Music Processing. Audio, Analysis, Algorithms, Applications*, Heidelberg: Springer.
- Mynett, M. (2012), 'Achieving intelligibility whilst maintaining heaviness when producing contemporary metal music', *Journal on the Art of Record Production*, 6.
- Mynett, M. (2013), *Contemporary metal music production*, Ph.D. thesis, Huddersfield: University of Huddersfield.

- Mynett, M. (2017), *Metal Music Manual. Producing, Engineering, Mixing, and Mastering Contemporary Heavy Metal*, London: Routledge.
- Payne, J. (2012), ‘Kemper Profiling Amplifier – Practicalities and Potentials from a Producer’s Perspective’, <https://www.youtube.com/watch?v=Uulzb3fZF2k>. Accessed 25 May 2017.
- Shapiro, N. N. (2017), ‘The Vocaloid “Genre”’, *The Odyssey Online*, <https://www.theodysseyonline.com/the-vocaloid-genre>. Accessed 16 July 2017.
- Sneap, A. (2012), ‘Kemper Profiling Amp - Artist Talk with Andy Sneap’, <https://www.youtube.com/watch?v=Nb1zI6pEu0A>. Accessed 25 May 2017.
- Sneap, A. (2014), ‘“You can even Beat your tone with the Profiler” Andy Sneap in Interview’, <https://www.youtube.com/watch?v=S1GvxldhZDQ>. Accessed 25 May 2017.
- Stephens, M. (2015), ‘It Might Get Loud: Amps of the British Invasion’, *Guitar & Bass Classics. Guitar Amp Bible 2015*, pp. 6-13.
- Taylor, M. (2011), ‘Interview: Metal production guru Colin Richardson’, *Musicradar*, <http://www.musicradar.com/news/guitars/interview-metalproduction-guru-colin-richardson-400260>. Accessed 25 May 2017.
- Théberge, P. (1993), *Consumers of Technology. Musical Instrument Innovations and the Musicians’ Market*, PhD thesis, Concordia University.
- Théberge, P. (1997), *Any sound you can imagine. Making music/consuming technology*, Hanover: Wesleyan University Press.
- Théberge, P. (2001), ‘“Plugged in”: technology and popular music’, in S. Frith, W. Straw and J. Street (eds.), *The Cambridge companion to pop and rock*, Cambridge: Cambridge University Press, pp. 3-25.
- Théberge, P. (2004), ‘The Network Studio: Historical and Technological Paths to a New Ideal in Music Making’, *Social Studies of Science*, 34:5, pp. 759-781.
- Uimonen, H. (2016), ‘Celebrity Guitars: Musical Instruments as Luxury Items’, *Rock Music Studies*, 3:3, pp. 1-19.
- Vinnicombe, C. (2012), ‘Kemper Profiling Amp’, *Guitarist*, May 2012, pp. 119-122.
- Walser, R. (1993), *Running with the Devil. Power, Gender, and Madness in Heavy Metal Music*, Hanover, NH: University Press of New England.
- Wagener, M. (2013), ‘Kemper Producer Talk – Michael Wagener’, <https://www.youtube.com/watch?v=32kBaZFPzHs>. Accessed 25 May 2017.
- Weissberg, D. (2010), ‘Zur Geschichte elektroakustischer Instrumente aus dem Blickwinkel der Körperlichkeit’, in M. Harenberg and D. Weissberg (eds.), *Klang (ohne) Körper*, Bielefeld: transcript, pp. 91-104.
- Williams, D. (2015), ‘Tracking timbral changes in metal productions from 1990 to 2013’, *Metal Music Studies*, 1:1, pp. 39-68.

Appendix

Table 7. Overview of the amplifiers and their characteristics

<i>Amplifier</i>	<i>Output</i>	<i>Power amplifier valves</i>	<i>Character</i>
1 <i>Bogner Goldfinger 90</i>	45	EL34	UK
2 <i>Earforce 4500 (Marshall modification)</i>	50	EL34	UK
3 <i>Engl Powerball E645 MK I</i>	100	6L6	US

4	Fender Super-Sonic	22	6V6	US
5	Fender The Twin (Red Knob)	100	6L6	US
6	Fryette Sig:X	40	KT88	US
7	Laney GH 50L MK II	50	EL34	UK
8	Marshall 1987X	50	EL34	UK
9	Marshall JCM2000 TSL	100	EL34	UK
10	Mesa Boogie Triaxis Vintage Mesa Boogie MK I with 2:20 power amplifier	20	EL84	US
11	Mesa Boogie Triaxis MK II with Peavey 5150 power amplifier	120	6L6	US
12	Orange Dual Terror	30	EL84	UK
13	Peavey 5150 MK I	120	6L6	US
14	Real Guitars Eddie MK II	50	6P1P-EV	US
15	Splawn Quick Rod	50	EL34	UK
16	Vox AC15	15	EL84	UK

Note: All amplifiers have 12AX7 preamplifier tubes except for the Real Guitar, which has 6N2P.

Table 8. Overview of the signal descriptors

Group	Descriptors
Loudness / intensity	Loudness (Sone), Maximum RMS Position (frame index), Maximum RMS Value, RMS Energy, RMS Energy Gammatone 1-10
Spectral composition & 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 sec)
Envelope & temporal distribution	Envelope Flatness, Envelope Kurtosis, Envelope Quantile Range, First Attack Leap, First Attack Slope, First Attack Time (sec), First Attack Time Gammatone 1-10 (sec), Length Trimmed (sec), Low Energy (%), Release Time (sec), Release Time Gammatone 1-10 (sec)
MFCC	MFCC 1-13
Spectro-temporal composition	Harmonic Energy (RMS), Percussive Energy (RMS), Melodic Contour, Spectral Flux (Median)

ⁱ 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).

ⁱⁱ 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.

ⁱⁱⁱ All audio files are available in the digital Appendix: [INSERT LINK](#)

^{iv} <https://www.gearslutz.com/board/so-many-guitars-so-little-time/1124029-amp-sim-people-hate-amp-sims-2.html>

^v <https://www.gearslutz.com/board/so-many-guitars-so-little-time/1115828-kemper-worth-money.html>

^{vi} <https://www.gearslutz.com/board/so-many-guitars-so-little-time/905072-kemper-real-amps.html>

^{vii} www.ultimatemetal.com/forum/threads/kemper-profiling-amp.832189/page-49

viii www.ultimatemetal.com/forum/threads/kemper-profiling-amp.832189/page-32

ix A detailed list of the signal descriptors, their explanation and respective references are in the digital Appendix: **INSERT LINK**

x RMS means "root mean square" and denotes the average loudness of a signal.

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

xii 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.

xiii 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).

xiv 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.

xv Shapiro (2017) even argues for the existence of a "Vocaloid genre".