# Musical Expressivity and Body Motion in Electric Guitar Playing

Pre- and post-processing in recording electric guitar

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# Abstract

*A lot of guitarists entering a studio bring their own guitar, effects pedals, picks, strings and cables—sometimes their amp(s)—to sound like themselves when recording, or to create the sound they are familiar with and have spent years developing and master. If the producer or studio technician decides to re-amp the guitar signal, and plug the guitar straight into the recording desk (or a DI-box) sonic outcome can be tweaked beyond recognition. Both in studio and in the clubs, electric guitarists try to re-create the sound they have been used to perceiving, to play their best, and in this interdisciplinary study I will show that the monitoring situation affects a guitarist's playing.*

*By designing an experiment where I simultaneously record the guitarists dry and wet signal, and control which signal they monitor, and using camera for recording their body motion, I can conclude that dependent on their monitoring, the guitarists alter their playing to a measurable degree, thus also changing the sonic outcome to some degree.*



Keywords: Electric Guitar Performance, Wet/Dry Monitoring, Sound Design, Body Motion

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# Preface

During many conversations spanning several years, in particular with three friends of mine—all of them musicians and studio owners—I have thought a lot about my own practice with recording music and reflected upon why and how I have come to work with music the way I do. The aforementioned friends all have different philosophies when it comes to how to produce music, both their own and others, thus their recording studios differs a lot in terms of space and equipment. All their studios are professional, and they also have in common that they are only doing commercial business to the lowest possible degree, to maintain the ability to work creatively with projects of their own choosing, and not out of economical necessity. (How this choice affects their lives, is another story.)

I have been lucky enough to work professionally with all of them on different levels, and being good friends, we also frequently meet outside the studios. So the conversations continues, and viewpoints will surely still be altered.

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# Abbreviations and words, as used in this thesis

DAW = digital audio workstation (e.g. Logic Pro X, Pro Tools, Cubase)

amp = (guitar) amplifier

cab = speaker cabinet

sim = simulation

cab-sim = speaker cabinet simulation

DI = abbreviation for «direct input», commonly used when plugging e.g. an electric bass directly to the mixer (normally through a DI box, taking care of impedance and such). In this thesis it is used for the signal acquired when plugging the electric guitar directly into the sound card.

sound card = external sound interface with inputs and outputs, connected to a computer typically via USB, firewire or thunderbolt.

stompbox, effects pedal, guitar pedal, pedal, guitar effect = used interchangeably, refers to the analog or digital boxes connected in the electric guitars signal chain, between the guitar and the amp (or in the amp's effects loop), that when stomped on (means turned on using the footswitch) alters the sound of the guitar. Typical effects pedals include: fuzz, distortion, overdrive, reverb, delay, chorus, flanger, phaser and wah-wah.

*«For all too many popular music scholars, musical activity does not exist for all intents and purposes before the moment of recording. Such an assumption, whether explicit or unspoken, leaves scholars to concentrate upon a range of issues that, while of key importance, tend to exclude the ways in which instruments figure into musical practice and production.»*

(Waksman 2003, p 253)

# 1 Introduction

The technological development of the past decades has had a huge impact on music production, and made it available and affordable for anyone with a decent computer, microphone and a soundcard. Bedroom recording is not new; Tascam Portastudio (aka Teac 144), a portable and affordable four-track recording system was released in 1979[1]. This was the first system based on the compact cassette, and made multitrack recording available for a whole new generation of young musicians without a record deal. Today, recording an almost unlimited number of tracks pre- and post-processed with extremely powerful sound shaping tools and mixing abilities are just a click away.

A lot has of course changed in the way we record music now, compared to 1979. Even going back only one decade one will certainly notice a lot of difference, like better and cheaper plug-ins, soundcards with higher resolution and better built-in preamps, making a bedroom recording moving closer to the professional recording. In addition I have noticed that friends and acquaintances running or working in professional studios, uses re-amping more often.

Re-amping is a technique where the recorded signal (most commonly an electric guitar) is sent out from the mixer or soundcard, into a (guitar) amp, mic'd up and re-recorded. This way one clean guitar recording can be tested out on different amps with different effects, and this is after all just another way to alter the sound of the already recorded electric guitar, to make it sit better in the mix, just like every other sound-manipulative technique done post is.

But if re-amping becomes the norm, rather than the exception, how does it affect the recording itself? In the most extreme case, it could mean the guitarists just plug the guitar straight into the mixing desk or soundcard, and just records a clean direct signal, for later re-amping and adding of effects. In such a case, it is natural to wonder whether musicians will alter their playing style or not. If guitarists don't (have to) use their own equipment—things they've spent long time fine tuning to their personal taste, creating their personal sound—will it affect the way they express themselves musically? If the sound when playing is not as expected, will it affect their body movements, and will it eventually lead to a different sonic output?

Famous electric guitar virtuoso, composer and producer, Steve Vai, express that he will «be first in line at the music store to purchase it», (Bjørn, Harper, 2019) referring to «the next great stompbox» (ibid), and states that:

> *«Effects pedals are to the guitarist what paint is to the artist. They are the colors that a guitarist mixes together and uses to paint the audio tapestries of their sonic expressions, and there is certainly a myriad of stompbox colors to choose from, with more and more being added every year»*
>
> Steve Vai, foreword in *Pedal Crush* (Bjørn, Harper 2019, p 5)

[1] https://en.wikipedia.org/wiki/History_of_multitrack_recording#Home_systems Last accessed 02.04.2022

Not all guitarists are as affectionate about stompboxes as Vai (and I), but many of us will recognize how these small gadgets becomes a part of who we are as guitar players, and part of our sonic universe.

## 1.1 Motivation

I am a stompbox-aficionado, and over the last 30 years I have bought, swapped and (sadly) sold a lot of them, along with vintage and new synthesizers, guitars, basses, and some studio equipment. I mainly experiment with sound, also when composing, and I prefer the hands-on experience that only hardware can provide. My interest quickly turned towards sound rather than technique when using different instruments. And I have always preferred hardware over software.

When I make and record music, I do most of it myself in my own home-studio, and I strive to record the sound I'm looking for, using hardware, rather than using software for shaping it afterwards. That means there is no undoing to the sound ending up on the tape or hard-drive. In the creative process, I also like to create restrictions and rules for my creative work: i.e. to use something of all recorded ideas in a project in the finished composition, with as little post-processing as I can get away with, without compromising the initial idea. The shaping of the sound is a process that started when I got my first effects pedal, and it continues today and into the future. I firmly believe that my musical expressivity is affected by the sound I perceive when playing, and I also believe that my body will move differently when the sound changes, or is not like I expect it to be, and this will most likely lead to another sonic outcome. To me re-amping as a method is not the musicians way, but at the same time I have no problems in understanding how it can help the producer achieving the sound they are looking for.

And to be able to run a professional studio, it would seem counterproductive to live by too many dogmas related to this matter. Artists and bands want to sound their very best and the producers job is to help them achieve their goal, preferably within their budget as well. With todays technology with easy and affordable access to digital processing, you can basically record clean signals that are not peaking, and do all the sound-shaping afterwards.

A finished recording is interesting in different ways for different groups of people, mainly two groups: the consumers/listeners, and the producers/musicians. For both groups, the main goal of the recording session is the end product—or *the what*. *The how* and *the why* is of very little importance to the consumers. They will not care if the drums are recorded with trigger microphones and sampled drums, with one mic in the room to a tape recorder, or if it is a drum machine, as long as it sounds right in the music and lives up to their expectations. Of course, a lot of them care a lot about the sound and the production, and can even talk and write articles about *the how* – how a recording has been done, and how a sound has been put to tape or hard drive, and the same article would gain on talking to the people involved in the recording, to find out about *the why* – why did they use an old drum machine and not their drummer, or why did *Radiohead*-producer Nigel Godrich plug Thom Yorke's guitar directly into the mixing desk when recording the song *Bodysnatchers*?

But this interest will always come after the recording is done, because of the sound, or a general interest in the artist or band. There is little interest for *the how* and *the why* beforehand, except by the producers/musicians. For them the process can be just as important as the end result, or the process causes the end result one might argue. Even though everything is possible to do post, producers/musicians often tend to do things in certain ways, with certain types of equipment and so on.

> *«[Nigel] Godrich is also a massive gear nerd. One of the mixing desks used on the album was a 24-channel Audiotronix console that he got from a studio in L.A, and was allegedly used on a bunch of Motown records. For Yorke's crunchy rhythm tone on Bodysnatchers, Godrich [sic] his guitar direct into the console, harnessing its warm, natural distortion and gifting the album with its heaviest number (and one of its most memorable moments).»*[2]

I believe the sound itself would be possible to achieve doing everything digital, but this also lead me to the psychology of *the why*. I can hardly believe that e.g. Steve Vai, Eric Clapton, David Gilmour or any other guitar legend famous for their tone would go to a studio session to plug their guitar directly into the mixing desk and let the producer crank the gain into heavy distortion. Would anyone hire Santana for a solo, and re-amp his guitar into a clean transistor amp (e.g. Roland Jazz Chorus) instead of the signature sound he gets from his tube Mesa Boogie? The musicians that have experimented with their sound might be depending on it to play the way they play, or at least to perform their best.

## 1.2 Theoretical background

In this section I will present literature related to my interest in this vast interdisciplinary field, where both cognitive psychology, music/sound perception, physics and materials science, human movement science, sound design, acoustics, and acoustemology as well as musicology and music technology. Despite the vastness of the field this thesis touches upon, I have narrowed it down to a varied selection of literature that again opens my research to other disciplines. Steve Waksman argues that «all too many popular music scholars, musical activity does not exist for all intents and purposes before the moment of recording» (Waksman 2003, p 253), and that this «leaves scholars to concentrate upon a range of issues that [...] tend to exclude the ways in which instruments figure into musical practice and production» (ibid, p 253). Having a huge interests in stompboxes, guitars, amps, synths and other musical gear, and how these objects can be experimented with and combined to create new sounds, new landscapes, new colors and ultimately new experiences, I find it strange that these matters have not caught the attention of scholars. And as I have tried to outline in section 1.1 and the

[2] https://happymag.tv/engineering-the-sound-radioheads-in-rainbows/ Last assessed 31.03.2022

preface, my (and I would argue every musicians') musical practice mostly takes place pre recording, and in this thesis I will take a closer look at one thing that might happen when musical practice meets recording sessions.

### 1.2.1 Distortion

Jan-Peter Herbst seems to agree with Waksman's statement 15 years earlier: «Despite this wealth of literature, there is still a profound lack of academic writing on what equipment rock guitar players choose to use and what goes into these choices.» (Herbst 2019, p 76). His article in Current Musicology No. 105 has «its source in a larger empirical research project on the distorted guitar in rock music, which focuses on distortion's effect on playability and expressiveness [...] its influences on chord perception, song-writing, and production» (Herbst 2019, p 96). The source research is mainly his own, and relates mostly to metal music and the use of distortion on an electric guitar. To no (ones) surprise he could in 2018 «confirm[...] distortion's relevance for heaviness from the listener's perspective» (Herbst 2018, p 110), heaviness understood as piercing high frequencies, great loudness and harmonic dissonance (Herbst 2018, p 96). With a listening experiment, he also found that the more complex the chords where, and the more distortion added to them, the less pleasant the participants experienced it, except for the «[m]etalheads [who] seem to be only marginally affected by sensory dissonance» (Herbst 2019, p 95).

His 2019 study «contributes [with] multifaceted data on the rock guitar to popular music studies largely missing so far» (ibid, p 77), asking questions like:

> *«What are players' attitudes toward sound quality, and how do they approach crafting a personal sound? To what extent are players concerned with pursuing traditional guitar sounds?»*
>
> (Herbst 2019, p 77)

More than 400 guitarists, ranging from amateur to professionals, answered a questionnaire (in German), and ten international renowned professional guitarists where interviewed. Among his findings was that within alternative rock the guitarists tended to vary or adjust sound more than in other genres, and that creating a personal sound was more important than an innovative sound. The quality of the guitar sound was very important to the interviewees, and the more metal oriented among them were used to shape the guitar sound together with the producer: Christopher Amott of Arch Enemy stated he «will, together with the producer, mix and match different tones from different amplifiers and experiment with different settings and effects. This means sometimes recording with an 'uncomfortable' sound» (ibid, p 82). These findings seems to add up with my conversations and discussions with musicians in different genres, also metal, where re-amping occurs more frequently in my experience. Also noted here is that guitarists in this study—also metal guitarists—tries to produce their guitar sound with as little post processing as possible.

In 2017 Herbst researched the use of distortion and the developing of shredding (a very fast playing technique mainly found in metal genres), and his analysis showed that «distortion changes the guitar from a percussive to a compressed and sustained instrument» (Herbst 2017, p 11) and argues how the rock and metal players using distortion have become experts of controlling the sonic output of a distorted guitar, using techniques like palm muting, and also highly synchronization of both hands to be able to play fast. Even though heavy distortion extends an electric guitars notes, one is always close to the tipping point where the note might spiral into uncontrolled feedback and sonic chaos. Faster playing is a way to ensure that from happening, but a very tight and synchronized technique is required.

As Herbst points out in his studies, many scholars in popular music has done descriptive studies on guitar related matters e.g. distortion; which is measurable and easily comparable to for instance a clean sounding electric guitar. But very little had been done prior to Herbst (2017; 2018; 2019) to try to figure out what goes into the guitarists choice of gear, techniques, and how they and the audience perceive the sound they produce. This thesis will hopefully contribute to the subject.

### 1.2.2 Electric guitar

The electric guitar has been subject to many different studies and a lot of literature exists on different topics surrounding this instrument. Steve Waksman's *Instruments of Desire* (Waksman 1999) is both a historical overview of the development of the electric guitar, as well as the importance of it with regards to cultural identity and ethnicity. The book focuses on key performers throughout the history, like Muddy Water, Jimi Hendrix and Jimmy Page, and—to use Waksman's words—his subjects are quite «representative of the social, political, and aesthetic limits that have defined the electric guitar's use as well as the sense of open possibilities that has driven so much of the instrument's history» (Waksman 1999, p 281). The sense of open possibilities is not explained, but I read it as the multiple affordances of the electric guitar. It is an instrument that—besides being play-able with everything it includes (playing soft, making noise, composing et cetera)—also is smash-able (Kurt Cobain, Pete Townshend, Jimi Hendrix et al.), setting-on-fire-able (Jimi Hendrix), throw-in-the-air-able (Kurt Cobain et al.), make-owner-a-legend-able (Jimmy Page, Van Halen, Eric Clapton et al.), and the list could go on. The electric guitar—especially when thinking about the typical guitar hero—is not only about the music; it's just as much about the musician, the person with the guitar around his or hers neck.

### 1.2.3 Fetishism

And for this person, the guitar might very well be the subject of commodity fetishism. Jonathan Sterne «argue that we must understand commodity fetishism as a real force in sonic culture» (Sterne 2019, p 95). Not only the guitar itself—as a physical object, a commodity—but the sound it produces, can be subject to commodity fetishism, according to Sterne (ibid, p 96). But it only occurs within—and its existence is dependent on—a social context and practice, and it is insoluble from the object itself.

Instead of talking about sound as a commodity, in my case it makes sense to use the word «tone» instead, at least sometimes. While sound of a guitar often refers to the sound of any guitar, the tone of a guitar is used more subjectively, connected to specific objects, not only the guitar. To achieve the sound of Jimi Hendrix on *Voodoo Child*, one can not simply buy any electric guitar from the local music retailer. After a little research one buys a Fender Stratocaster Jimi Hendrix signature (to at least have the other angled bridge pickup and the long low E, due to the reversed headstock), maybe a Jimi Hendrix Signature wah from Dunlop, and a round fuzzpedal (could also be a JH signature) from the same company and an amp, and the sound might hopefully be close enough, otherwise it might be an expensive road to go down, with no end to it. The commodity in such a case is the tone, whereas the objects are the tools needed for creating the tone. Needless to say, the fetish is not just only about the tone, both the objects and the sound they make «becomes part of the commodity fetishism» (ibid, p 96).

> *«Timbre is the dimension of sound that explains how a violin and a piano playing the same note at the same volume can still sound entirely different from each other. While timbre (or "tone color") is notoriously difficult to define, it is also the key to the fetishism of instruments. To speak of an instrument's spectral objectivity is thus to simultaneously reference the web of social relations in which it exists and the sonic history of which it is a part. I intentionally distinguish these phenomena from the sounds the instrument makes, because instruments cannot make sounds independently of their playing—this is true even for automated instruments like player pianos or sequenced synthesizers. For musicians who play stringed instruments, this is embodied in the old cliché, "The tone is in the hands." At the same time, certain instruments come to be associated with certain performance styles, genres, and timbres. People want certain kinds of instruments because they want certain kinds of sounds—or, at least, to plug into those histories of sound. The (sonic) spectral objectivity works only because of the (social) spectral objectivity of the instrument.»*
>
> (Sterne 2019, p 97)

And when considering that the tone and timbre not only is produced by the guitar or the hand alone, but comes from what Mitch Gallagher refers to as the electric guitar system, and when also considering that «[t]he smallest change in nearly any component in an electric guitar system […] can affect the tone» (Gallagher 2012, as cited in Fink et al. 2018, p 5), there are a lot of objects that might be subject to commodity fetishism.

The electric guitar system is made out of the guitar itself, which consists of a body and a neck, both usually—but not always—made of wood. Then there are strings (coated/ non-coated, hex or round core, steel/nickel, round- or flatwounds, different sizes and so on), pickups, wires and other electronic components, as well as different hardware made from different metal alloys. Then you have the amplifier with even more

components, effects pedals with its electronics, cables connecting everything, and the speaker in its cabinet, the latter also made of wood and in countless configurations. And the most important part of the guitar system—some might argue, including Gallagher (ibid, p 6)—is the guitarists themselves. Do they use a pick, and if so; what kind of pick? At what angle does the pick meet the strings? Where do they hit the strings? How hard is the excitation? And so on. There are a lot of ways to make the exact same guitar system sound very different only by playing differently, even the players mood and emotion is changing the sound (ibid, p 6).

### 1.2.4 Tone and timbre

So in the signal chain of the electric guitar system, there are a lot of objects that is subject to fetishism, but as Sterne argues, it is the timbre—and I will add and use tone—that is the key to instrument fetishism (Sterne 2019), and it is «when an instrument is in the hands of someone else that its fetish character is most effective, for this is where it most fully points to a set of social relations that are otherwise unavailable to the senses» (Sterne 2019, p 107). By instruments I will assume Sterne means objects in the signal chains, like the guitars, stompboxes (or other guitar effects, like racks), and the amps. We can not grow David Gilmour's fingers, but if we have the money—depending on availability—we can buy equipment he has been famous for using, like a '69 Fender Stratocaster with a maple neck and fretboard, a vintage EHX Big Muff, a MXR Dynacomp and a Hiwatt DR103 amp head and so on. Any decent guitar player would sound good with this equipment, but it would probably kill the magic as well, as no one would sound like Gilmour, but David himself.

Another side of the fetishism amongst guitar players has to do with certain types of wood: Les Paul's *the Log* became «[o]ne result of Pauls's quest for ''pure string vibrations''» (Waksman 1999, p 43). The idea behind the Log was to isolate the electric signal from the acoustic properties of the guitar, which interestingly contrasts with many of today's electrical guitarist's quest for the perfect tone, a quest that typically includes most any component in the guitar system, also including what often is referred to as «tonewood». There are lots of online debates on the matter, both on youtube and guitar forums. And while many people swear that the sonic differences between different types of wood in an electric guitar is apparent, research often concludes with the type of wood is an unsignificant contributor to the guitar's tone (Soper 2007) or at best it has «some influence on the vibro-acoustic properties of the guitar body» (Ray et al. 2021, p 11). Ray et al. concludes that softer wood dampens the strings (plucked open, one at a time) more than harder wood, resulting in a faster decay. But when the electric guitar is in use—in the electric guitar system—the contribution from the wood in the guitar body will be reduced even further.

### 1.2.5 Legendary tones & technique

«Carlos Santana's legendary tone» (Fink et al. 2018, p 212) is subject to Melinda Latour's chapter in *The Relentless Pursuit of Tone: Timbre in Popular Music* (Fink et. al 2018). Santana chose his gear, and developed his playing technique for the purpose of

longer sustaining notes. Instead of working with effects pedals he mainly used his volume knob and amplifier settings and feedback to achieve this, as well a a wah-wah pedal. The wah-wah pedal is a bandpass filter, where the frequency spectrum is shifted by rocking the foot pedal back and forth, creating the guitar sound of Isaac Hayes' *Theme from Shaft* (1971) or Jimi Hendrix' *Voodoo Child* (1970), or Rage Against The Machine's *Bulls on Parade* (1996). «Santana […] avoids this ''wah'' sound, instead using the pedal more as it was originally intended, as an infinitely adjustable shaper of subtle tone variants. He slowly shifts the pedal on a sustained note until he finds a sweet spot […] and leaves it there.» (Fink et al. 2018, p 216). Why Latour seems to mean that slow shifting to find the sweet spot is closer to the original intended use, is unclear. The story about the wah-wah pedal is a little fuzzy in itself: Brad Plunkett, an engineer at the Tomas Organ Company, is normally credited as the inventor of the wah-wah pedal. But reading Del Casher's story in Tom Hughes' *Analog Man's Guide To Vintage Effects* (Hughes 2004) raises questions to whether it was Casher himself, and not Plunkett, who was the actual inventor. «I really wanted the wah-wah pedal to compete as a voice, like the horn players, but I didn't want the horn players to be using my instrument, my wah-wah pedal» he says (Hughes 2004, p 29), referring to how the CEO of the company, Joe Benaron, wanted to sell it to the trumpet players instead of to the guitarists. That is also why, according to Casher, the wah-wah pedal still is associated with the trumpetist Clyde McCoy. The way Santana uses it though, can hardly be heard as mimicking the sound of horns, but instead he use it to accentuate a specific and narrow part of the frequency band, and as Latour puts it: «these imperceptible shifts in the range of overtones that pass through the filter gently explore the interiority of the tone without changing the pitch» (Fink et al. 2018, p216). The way Clyde McCoy used his mute (on Sugar Baby, 1931, i.e.) is clearly a much more profound wah-wah sound than the almost imperceptible shifts Santana is famous for.

### 1.2.6 Technological development

New technologies have opened up new possibilities for production and development, and new commodities subject to fetishism. Most of the fetishism I have discussed applies to the more mythical and vintage sought after instruments and equipment. In his book *Any Sound You Can Imagine: Making Music/Consuming Technology* Paul Théberge argued 25 years ago that «[t]o a large degree, the days of the inventor/entrepreneur are over. The production of electronic musical instruments is today dominated by large corporate concerns» (Théberge 1997, p 70), but this is luckily not true today. He introduces the book with the scepticism synthesizers (including drum machines) in particular and other new technology have been met with, especially during the 70's and 80's (ibid, p 1). Some of the negativity was due to the homogenization of music some people felt this new technology, with presets available at the push of a button, led to (ibid, p 1).

But looking at the today's hardware synthesizer industry, where large companies like Korg, Moog, Roland, Yamaha, Behringer and other dominate the retail-marked, due to capital and effective production lines, there are still inventors and entrepreneurs in the market. Newer companies like Teenage Engineering, Arturia, Dreadbox and others are

the true entrepreneurs of today's synth-business, with their OP-1 and PO-series (Teenage Engineering), their Microfreak (Arturia) and the Medusa (Dreadbox together with Polyend). The granular synthesizer GR-1 from the tiny Dutch company Tasty Chips Electronics, should also be mentioned, as one of the first—and most complete—hardware granular synthesizer, with functionality only seen in powerful software earlier.

Moving into the stompbox-market, one can register the same trends. Classic and huge brands, like Boss, MXR, Ibanez and Electro Harmonix (the latter which also must be said to still be in the forefront of new development) might still have the biggest sales number, but some of the most sought after new pedals—as well as the most groundbreaking inventions—are to find among brands and start-ups from the 2000's: Strymon (US, 2004 as Damage Control), Chase Bliss Audio (US, 2013), Hudson Electronics (UK, 2007), Pladask Elektrisk (Norway, 2014), Montreal Assembly (Canada, 2007), Red Panda (US, 2016), Drolo FX (Belgium, – ), Hologram Electronics (US, 2015) and Gamechanger Audio (Latvia, 2015), to name just a few. These are everything from small one-man companies, selling out every new batch of their most popular pedals in minutes or hours (Drolo FX [I tried once again to get a hold of a *Drolo Stamme[n]* restocked at May 26th 2022 16:00 Brussels time, but again with no luck, they were all {at least 40 pedals} sold out at 16:02], Pladask Elektrisk) to medium sized companies with a more streamlined production chain (e.g. Strymon, 42 employees[3], Chase Bliss Audio, 20 employees[4]), many of them having waiting lists for their pedals. Mentioning these companies can be regarded, and are of course, subjective, but an electric guitarist with an over average interest for stompboxes would definitely agree, and add/subtract from the list[5] of guitar pedal manufacturers.

After Théberge's claim in the late nineties, the effect pedal industry in particular has undergone something close to a revolution. Not only are analog stompboxes popular as ever before, but also the development of new powerful and affordable digital technology has created almost unlimited sonic possibilities for the adventurous guitarists, which again could counteract the musical homogenity mentioned earlier.

Returning to commodity fetishism; stompboxes—vintage as well as new—are subject to it, both because of the sound they help musicians achieve, but also as objects in itself. When people (online) refer to NPD, numerous stompbox-aficionados—like myself—are eager to know which pedal they got on their New Pedal Day. (I had my last NPD just yesterday, when finding a vintage stompbox from Electro-Harmonix, perfectly fitting into my collection of bi-box pedal from the company).

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[3] https://www.strymon.net/about/

[4] https://www.chasebliss.com/about

[5] An almost complete list of effects pedal brands: https://mynewmicrophone.com/full-list-guitar-effects-pedal-brands-manufacturers/#Full-List-Of-Guitar-Effects-Pedal-Brands/Manufacturers

### 1.2.7 Body motion

When creating or working with music our bodies are in motion, and in *Musical Gestures: Sound, Movement, and Meaning* (Godøy et al. 2010) a multitude of angles on the matter is presented:

Musical gestures is explained as «human body movement that goes along with sounding music» (Jensenius et al. 2010, p 13) and further divide them into «the gestures of those that produce the sounds (the musicians), and the gestures of those that perceive the sounds (the listeners or dancers)» (ibid, p 13). Why the movements are denoted as *gestures* instead of movements, is to «blur the distinction between movement and meaning» (ibid, p 13), or simply put; to add (more) *meaning* to the movement. Although I agree with the rationale for using the term *gestures*, I prefer to use *body motion* or *movement* in this thesis, to underline the absence of musical will—or meaning—in their displacement of body, it is more a spontaneous bodily reaction to (unexpected) sound. This not entirely the case though, because the observed musicians in my experiment adapt and adjust to the sound they perceive, thus using the term musical gestures about their body motion is not at all wrong, but I believe their movements are adapted as a result of their perception, mixed with their sudden and adjusted will, or meaning.

Sofia Dahl et al. (Godøy et al. 2010) discusses the overlapping of the different categories of musical gestures of musicians, or performance-related gestures (Dahl et al. 2010, p 36)—as suggested by Jensenius, namely «sound producing, communicative, ancillary or sound facilitating, and sound accompanying» (Jensenius et al. 2010, p 13) gestures. Distinguishing or separating these observed gestures may be difficult (Dahl et al. 2010, p 36), but for this thesis the category of the highest interest is the sound-facilitating gestures, gestures «facilitating performance although not producing sound» (ibid, p 36), and again I will use the term sound-facilitating *movements*. And like Dahl I argue that there is a lot overlapping between the four categories, I would go so far as to say they are all in play at all time, at least when experiencing unwanted or unexpected sonic outcome of their musical practice: For instance, during a performance—starting in the sound-accompanying category—a guitarist's first reaction to an unexpected sound is «made in response to the sound» (Dahl et al. 2010, p 36), which is within the s*ound-accompanying* category, and then—in almost the same instance—the guitarist will physically adapt and *facilitate* «performance although not producing sound» (ibid, p 36), and probably *communicate* with others in the band or in the audience, before—still in the same instance—*produce sound*, altered or as previously intended.

## 1.3 Research questions

My interest lies mainly in the sonic domain, and how we react to what we hear. And many guitarist's spend years finding their own unique sound, and they do so by choosing gear, experimenting with gear and guitar techniques—in a broader term—including pure guitar techniques (rhythmic and melodic playing, shredding, bending, use of tremolo system and more), ways to use specific effects pedals in conjunction with the playing, combined techniques involving pedals and volume and/or tone-knob (some guitarists use them a lot, while others never touch them), amp-adjusting, use of

feedback, and other techniques used to form one's unique sound. So this is about expressivity through sound production, but I also believe musical expressivity physically manifests itself, through musical gestures, and through body motions as spontaneous reactions to sound. Peter Elsdon notes that «[a]ccording to jazz pedagogy […] swing has to be felt and cannot merely be imitated; it has therefore to be internalized and made physical in some respect» (Elsdon 2006, p 194). This suggests that physical expressivity in music not necessarily is «nothing more than superficial show-business posturing» (Moreno as cited in Elsdon 2006, p 192).

So what happens when we remove this personal touch during a recording session. By investigating re-amping techniques, multitrack recording and selective monitoring, I seek to find out:

*Does different monitoring affect the electric guitarist's playing/performance, subsequently the sonic outcome?*

Furthermore I am interested in if one's musical expressivity changes when monitoring situation changes. Musical expressivity covers a lot of a performance, I will mainly focus on energy and rhythmics, always with the performers body motion in mind, and ask:

*Is there a correlation between body motion, musical expressivity and sonic output?*

# 2 Methods

To explore these matters, two experiments were designed and executed, with in total five participants, three in the first experiment in March -22, and four (two from the first experiment plus two more) in the second experiment in April -22. The participants are all semi-professional or professional guitarists, and where asked to join due to their involvement in Oslo's music scene. The experiments were approved by NSD, ref.nr 195236, and all participants signed a consent form before participation. They were recorded and filmed during the experiments, but other than the filming no personal data were collected.

In both experiments a Macbook Pro, late 2013, running Logic Pro X, with an Audient Sono[6] soundcard connected, was used for audio recording.

To answer my questions I designed an experiment where two and three guitar tracks where recorded simultaneously, and the guitarists only had one of the tracks monitored when recording. In essens this should make me able to track changes in the recorded audio, depending on what kind of monitoring the guitarists experienced. They where also filmed, for me to analyze changes or patterns in their body motion, again based on the track monitored.

## 2.1 Experiment 1 – preparations

The first experiment took place at Sub Scene in Oslo, a live venue with capacity for 230 people. The guitarists had several options when choosing amplifier[7], but all three chose a Fender Twin Reverb. It was mic'd up with a dynamic Shure SM57 and placed in the room where the live-stage is. The guitarists where situated in a room next door—together with me, recording audio and video—using a Beyerdynamic DT 770 Pro 80 Ohm headset during the whole session, and they used (one of) their own guitars, but two of them also used some of my stompboxes[8] for the experiment.

The Audient Sono, an interface built with guitarists in mind, has a built in speaker-cabinet simulation from Two Notes. The interface also has the possibility to send the guitar signal out again, bypassing cab-sim, through a re-amp output. The routing I started the experiment with (fig. 1) made it possible to record three different signals in one take:

(I) Guitar signal (with stompboxes) and cab-simulation

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[6] https://audient.com/products/audio-interfaces/sono/overview/ Last accessed 01.04.2022

[7] VOX AC30 CC2 2x12 (combo), Fender Twin Reverb (combo), Epiphone Valve Jr (combo), Marshall JMC 2000 (head), Marshall JMV 410H (head), Dr Z Carmen Ghia (head), Dr Z 2x10 (speaker cab), Marshall 4x12 1960AV Angled Cabinet

[8] My personal pedalboard was used by two of the participants: TC Electronic Polytune Noir –> Origin RevivalDRIVE –> RMC Wah –> Pladask Elektrisk Draume –> Gamechanger Audio Light –> Gamechanger Audio Plasma –> EHX Deluxe Memory Man

(II) Direct guitar signal (with or without stompboxes) without cab-simulation (accessible as input 11 in the DAW from the same input)

(III)Amplified and mic'd guitar signal (with stompboxes)

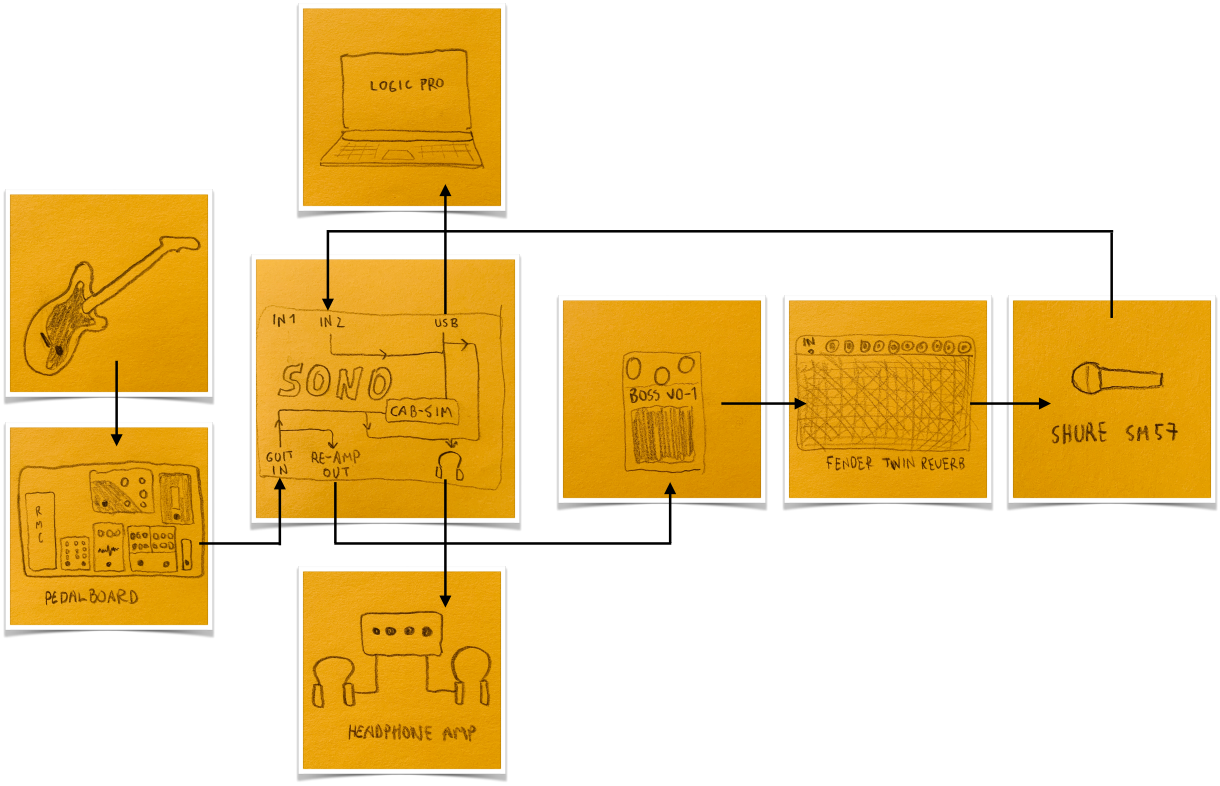


Fig. 1: Routing at the start of the experiment. Notice internal routing of the sound card. The Two Notes Torpedo remote was set to simulate a Fender Twin Reverb in a studio, mic'd with a dynamic Shure SM57 placed close to the speaker, resulting in little room reverberation. The order of the stompboxes is of less interest in this case, but is to be found in footnote 8.

This also made it possible to isolate each of these signals for monitoring through headphones during recording. The second option, with stompboxes, was recorded, but not used for monitoring at any time during the experiment.

For videofilming I used a Sanyo Xacti camcorder on a stand, and an iPhone 7 Plus with a 12MP rear-facing cameras with ƒ/1.8 aperture as a back up camera.

The sessions where expected to each last up to 60 minutes, and some of the conversation was also recorded.

Each participant chose beforehand what to play, a part of a song or own composition, lasting from 20 to 60 seconds. They also chose what effects to use (if any). In addition to their chosen piece they also had gotten a tablature of a simple melody to play.

### 2.1.1 Experiment 1 – execution

Before the guitarists arrived, everything was set up and tested. But being only me at the place, this was time consuming and not very efficient. The participants had chosen a 1

hour time slot for the session. During their set up I explained more in detail about the project, before we started testing and sound checking everything, and finding the right tempo (Logic's onboard metronome was used) for their chosen piece. Even though the glass, walls and door between the control room and the venue-room with the amp were not totally sound proof, there was very little leakage from the amp, when using headphones. With the headphone amplifier the guitarists were in control of the monitoring volume themselves.

We started to record their chosen piece three times when monitoring the amplified guitar signal, with stompboxes, three times monitoring cab-sim signal with stompboxes. To then be able to monitor the direct signal without stompboxes, some re-routing was necessary:

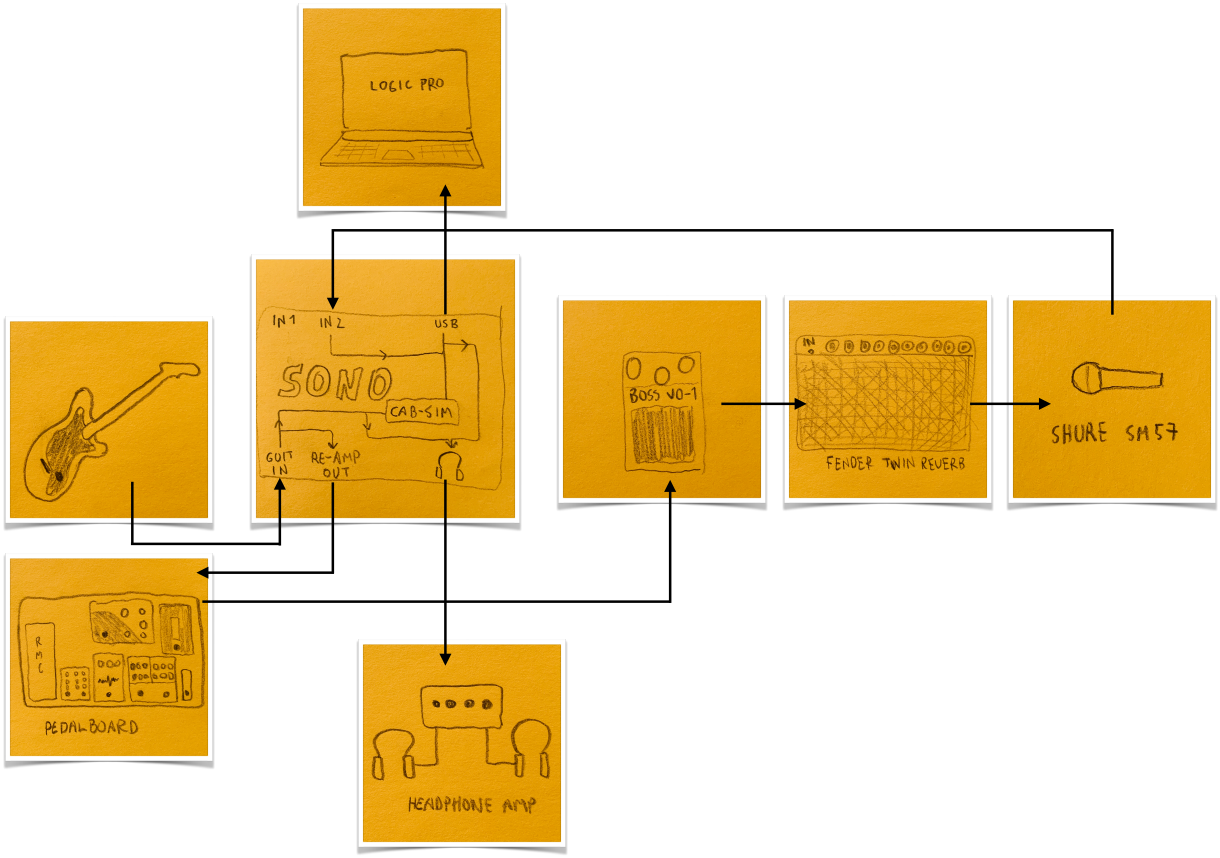


Fig. 2: Necessary re-routing, to be able to monitor the DI signal (no effects) and the wet signal.

As the illustrations (fig. 2) shows, the only thing that were changed was the placement of the pedalboard in the chain, which instead of its placement between the guitar and sound card, now where place directly after the sound card, before going to the amp. Two of the guitarists used the same pedalboard, and one of them used his personal pedalboard[9]. This routing made possible the most extreme case, as if one records the DI

[9] Participant's pedalboard: Fulltone Catalyst –> TC Electronics Forcefield –> Boss PS-6 Harmonist –> EHX Holy Grail –> Alexander Pedals Waveland (chorus mode) –> Proco Rat –> Way Huge Echo Puss

signal, and later re-amps it with stompboxes and a favorable amp. The only difference here was that recording of direct and re-amped guitar was done simultaneously. With setting up, explaining, sound checking, and recording their chosen pieces/excerpts, an hour were already passed, leaving no time to record the simple melody.

### 2.1.2 Experiment 1 – issues

During the execution of the experiment other issues were also exposed:

a) Randomization. Because of practical issues with randomization of the monitoring situation, the first experiment turned out—according to the Campbellian approach—as a *quasi-experimental design* as opposed to *experimental design* (Alferes 2012, p 2-3) as intended. I used a simple python-script for the randomization, but practical reasons (the necessary re-routing) made me skip it just before the execution. I can not be sure if the results would have been a lot different if I could randomize the order of the monitoring, but it seems likely that the guitarists could easier adapt to the monitoring due to the longer time of exposure to it. With randomization it should be easier to see correlating data for the same monitoring between the guitarists.

b) Technical issues. Everyone who has built some pedalboards have most probably run into buffering and leveling issues. This also happened here when re-routing the pedalboard. The Boss VO-1 was used at the end of both chains for it's buffering only, because of the long cabling necessary for the set-up with the amp. With the pedalboard directly in front of it, with the RevivalDRIVE having buffered bypass, and Draume[10] set to «trail»-mode (effectively being buffered bypass).
   This led to an unforeseen and considerable raise in the amp's volume despite no change in the settings. This was not considered a major problem, though, as long as it was consistent between the guitarists.
   There were also some technical issues with the camera, resulting in some missing data.

c) Consistency. Leaving most of the options to the guitar players makes it harder to acquire consistency in the data. Due to what I am investigating, I wanted to make the experiment as familiar to each participant as possible, thus letting them play what they wanted, with the equipment they wanted. Even though they all chose the same amp, and two of them also used my pedalboard (only using the Origin RevivalDRIVE), and the biggest change following this—in regards to equipment—was the different guitars they used, the difference between the musical pieces and the amount of effectuation. The third guitarist used his pedalboard but my guitar[11] with a longer scale than what he usually play.

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[10] A «toggle switch sets the bypass mode. **TRUE** yields true bypass. **GATE** yields true bypass with the addition of minimizing the reverb decay when the pedal is bypassed, effectively clearing the reverb memory. **TRAIL** yields buffered bypass with reverb trails.» (Pladask Elektrisk Draume, manual)

[11] Fender Jazzmaster Thurston Moore signature, 2009

d) Efficiency. The experiment was very time consuming, it was expected to last 40-60 minutes per participant, which is quite a lot, but lasted up to 1,5 hours, resulting in a lot of delays, and also forcing me to drop the melody line they all should be playing.

## 2.2 Experiment 2 – preparations

Learning from the first experiments, taking all experienced issues into consideration, I started preparing the next one. Even though I found some interesting examples of the guitarists clearly altering their playing when switching from re-amped to DI signal (see fig. 10 and 11, routing as illustrated in fig. 2), I needed to have more control over the experiment and the consistency between the players. I wanted the experiment to flow better, without any pause between the recordings with different monitoring to avoid for the guitarists to loose their focus.

I decided to use a more effect-drained example as inspiration for the final setup, mainly inspired from one of the participants, and made a simple «song» with pre-recorded drums and bass instead of the click (metronome) for the participants to play along with. This way it resembled more of a recording session where the guitarists were given a task or job to contribute to a «real» recording.

The rig for this last version of the experiment was made bike-transportable, to make it more flexible and independent of a fixed rig in a specific location. This meant I had to get rid of the amp in the new setup, which did not feel comfortable to begin with, since it takes away the a lot of the physical experience of moving air when playing the guitar. But in the end, most guitarists monitor the recording session through headphones, or from the control room anyway (but not always).

With the new setup/routing (fig. 3) and a portable rig (fig. 24), I could let the participant monitor either the totally dry DI signal, or a wet, effected signal with cab-sim. I tested a lot of different stompboxes in different positions[12] before deciding on the following equipment and routing, as illustrated in fig. 3.

The Neon Egg Planetarium 2 is a multieffect with a washy reverb going into a lo-fi modulated delay going into a compressor with internal sidechaining, all engaged during recording. The Ibanez FL5 was set with medium feedback and slow rate, but depth on full. The Zvex Inventobox is a Fuzz Factory and a Super Hard-On plus a tone stack, also all engaged in the experiment.

All of this, including a small headphones amplifier (Behringer HA400) and an Apple Powerbook fitted in a double electric guitar gig-bag.

For videofilming I used an iPhone 7 Plus with a 12MP rear-facing cameras with ƒ/1.8 aperture.

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[12] The order of the stompboxes is quite the opposite of what many youtube-videos and guitar forumers would consider as the most usual, and even correct way. I'm happy to see that an increasing number of guitar players have realized that there is no correct order in which effect pedals go, and that a lot of favorite bands from the 80's and 90's where likely to have a drive after e.g. a reverb and modulations, all dependent on what sound they'd like to make.

The sessions where expected to each last up to 15 minutes, and some conversation was also recorded.

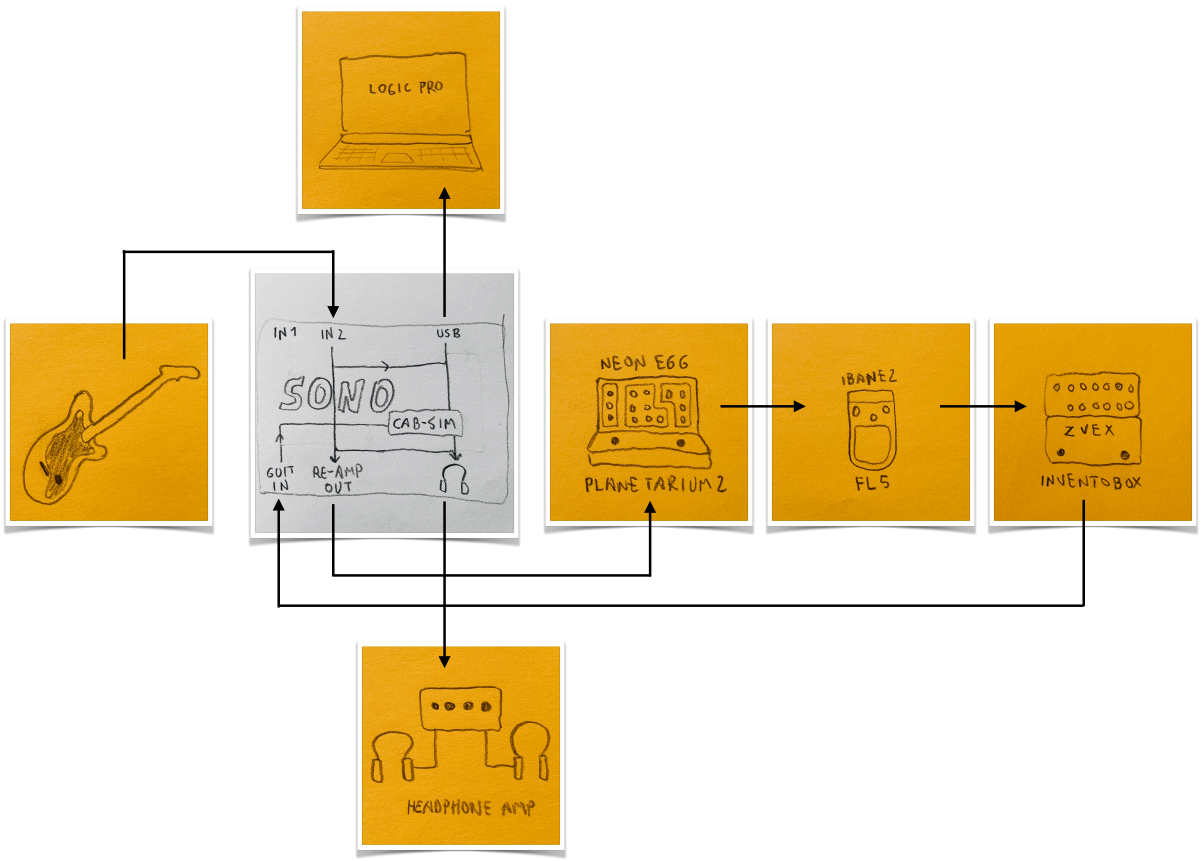


Fig. 3: Routing in the portable experiment lab. Notice the new internal routing of the sound card. The Two Notes Torpedo remote was set to simulate a Fender Twin Reverb in a hall, mic'd with a dynamic Shure SM57 placed approximately a hand away from the speaker, resulting in some room reverberation.

### 2.2.1 Experiment 2 – the song

The song had only one part of eight bars, repeated 16 times. I used three tracks of Logic Pro's drummer-function, and recorded a simple bassline on my guitar, and post-tuned it down one octave. The bass- and drumparts where 16 bars long, with very little variance, repeated eight times. The diagram below (fig. 4) shows the 16 bars that in total are repeated eight times. The eight bars in the middle are the ones I've been using for analysis. I did so to eliminate possible first reactions after a possible change in the monitoring, as the point is to figure out whether the monitoring-situation affects the playing, and not to measure a sudden surprised reaction to the rather big change the participants are exposed to.

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bm | Bm | A | A | E | E | E | E | Bm | Bm | A | A | E | E | E | E |
| 16 bar basspattern, four flats playing the keynote of the chords | | | | | | | | | | | | | | | |
| 16 bar drumpattern | | | | | | | | | | | | | | | |

Fig. 4: Diagram showing the recording pattern, repeated eight times, all in one take. The eight red bars in the middle are the ones extracted for analysis.

I also wanted to randomize the monitoring, and used a python-script to decide the order of the monitoring for each participant. I prepared eight projects in Logic Pro X for up to eight guitarists, and by marking (for «solo») and muting different channels according to what the script spitted out the possibility for recording all 16 bars eight times (128 bars in total) in one take and seamlessly changing the monitoring was possible by pressing S (abbr. for solo).

Fig. 5: Same project. Top right with «solo» engaged by pressing S lets the guitarists monitor all tracks but the “re-amp receive” (i.e. the wet) during recording. Left image shows how the “DI” track (i.e. the dry) is muted when solo is not engaged.

The illustration (fig. 5) show the labelling of each of the eight protions of 16-bars, labelled either «Wet» or «Dry». Note that also the «re-amp send» track is also marked to be soloed, as this is the track sending the direct guitar signal out the re-amp connection on the Audient Sono, and it needs to be “playing” at all times, to be able to record the re-amped signal, also when not monitoring it.

### 2.2.2 Experiment 2 – the participants

While I in the first experiment had a longer and very interesting conversation with all three participants, I focused more on what kind of guitar player they consider they are in this second and final experiment. We talked about the use of guitar effects pedals, and

other equipment. Some information was also collected after the experiment, verbally or via messages.

Four guitarists, two from the first and two new, joined this experiment in different locations: one in Berlin, Germany and three in Oslo, Norway. Two of the participants have formal music education, from three to five years. All four guitarists have more than 15 years of experience playing the electric guitar, and have recorded multiple sessions in different recording studios, contributing to several records. They all play in different bands today.

One of them owns about ten stompboxes, and use them to some degree, but do not usually change the sound many times during songs, and has no particular interest in the pedals themselves. He expressed his love for a good (shortscale) Fender offset[13] and a decent Fender amp. He owns three electric guitars.

Two of the guitarists estimates they own 40-45 stompboxes, and have several pedalboards for different use. They use pedal to a great extent, switching many effects on/off during songs, and they both have a «over average interest» in the field. They both agree to suffer from gear affection syndrom (GAS), and own several amps (five at the time, a very fluid and changing number) and (seven and nine, a little more stable) electric guitars.

The last guitarist is somewhere between, owning about 25 effects pedals, using approximately ten on a regular basis. He expressed stompboxes as the main area of interest in the guitar field, and owns two electric guitars. he also use more traditional guitar training exercises when rehearsing, like playing scales and figures, compared to the other three.

As a result I have decided to categorize them into two groups: [FX] and [NORM], where the two with the most effects pedals are in the [FX] category, and the other two in the [NORM] category.

### 2.2.3 Experiment 2 – execution

When entering the session, the participants were instructed to play the 16 bars eight times, without stopping (even if they played something they would normally stop because of in an ordinary studio session). One of my own guitars were chosen for all of them, a 2009 Fender Jazzmaster Thurston Moore signature, using the bridge pickup, volume on full (no tone control). An exception was made for the participant in Berlin, who played another guitar of mine, a 2008 Fender Jazzmaster J Mascis signature, bridge pickup, volume and tone on full, due to the other guitar's unavailability at the place (it was in Oslo, but everything else—plus the Mascis—was in Berlin). This is visible in some of the results (mainly due to other pickups and wiring, but also to some degree because it is another guitar made with different materials and hardware) and will be pointed out when applicable.

[13] Fender guitars with a skewed body, most usual are the Jazzmaster, Mustang and Jaguar.

The instructions where simply to think of it as a studio session, where they contributed to a recording, and I showed a basic strumming pattern as a platform for what I wanted. I showed them my open-chord version, but let them decide how to play the chords. I encouraged them to spice up the strumming pattern with some arpeggio or other melodic ingredients where they deemed it'd fit, but again they chose themselves if and how they would do it.

Before recording, they also heard and rehearsed a couple of bars with the pre-recorded material and with both monitoring situations, and they where instructed to sit down when recording.

A recording of 16 bars eight times (equals 128 bars) in 102 bpm takes just over five minutes to record, resulting in the whole session lasting from 15 to a maximum of 20 minutes in this experiment, including talking and set-up. 2.2.4 Experiment 2 – issues

This experiment ran very smoothly, and I was happy to experience how focused every participant was, and their enthusiasm about the whole thing. Even if there where no clear issues to it, I still had some concerns along the way:

a) Was the experiment too streamlined? Will I acquire any data with any consistency? As opposed to the first experiment, where I easily could see reactions to the monitoring, this one felt like all four participants actually where hired to do a proper recording session, and I could not visually or sonically register any difference in body motion or playing style throughout that I could pinpoint to the different monitoring situation.

b) The lack of using a guitar amp was my biggest concern pre to the execution. But it was the only way to make the experiment executable to the degree it was, and because of the sound card's onboard cab-sim from Two Notes Torpedo, the sound of an amp was present in the headphones. But the possibility to use the amp settings and feedback is of course not there, which means that the experiment would not be approved by many classic guitar legends, I believe.

c) The categorization of the guitarists is maybe not very precise. The guitarist owning 25 effects pedals could also be put in the [FX] category, as he uses pedals a lot. But in my mind he belongs to the [NORM] category, because he seems less obsessed with guitar related gear (not suffering that much from GAS as the two in the [FX] category), and more focused on guitar playing. The [FX] category could also be called [GAS], but focus in my thesis is not the affection for gear, but the use of effects pre or post, and how it affects the recording musician.

Despite my concerns, and possible issues with the experiment, the execution and data collection went better than expected, but only the results following can tell if the experiment was a success or not.

## 2.3 Analysis

I acquired video and audio in both experiments and all files where analyzed in different applications for different purposes.

Audio was recorded with a 44.1kHz sampling frequency and 16 bits per sample.

Video was shot in 1080p HD video (1920 x 1080 pixels) at 30 frames per second.

Both video and audio files where edited to the eight bars (18 seconds and 823 milliseconds) in the middle of the 16 bars. This gave me eight files of video, eight dry audio files, and eight wet audio files per participant.

### 2.3.1 Analysis – video

Video files where edited in iMovie and analyzed using the standalone VideoAnalysis application (Jensenius et al. 2005). Data retrieved from VideoAnalysis where further analyzed in python using matplotlib to create graphs.

After editing to correct length in iMovie, the eight video clips (per participant) where exported as 1080p HD, and imported to VideoAnalysis. The settings and crop in VideoAnalysis was the same for all clips for each guitarist. I cropped the video to limit the analyzed window to the person with instrument only. Proper lighting in the recording rooms made sure there where no movements in the background of the image.

In VideoAnalysis I decided to use inverted greyscale instead of colors, as it is preferred «to work with grayscale motion images since colours often seem to be more of a distraction than help». (Jensenius 2006). The inverted color scheme was further chosen to anonymize different exported images and videos even more. The rest of the settings were kept at default values, except for the cropping, which differed between the participants (fig. 6). The exported csv-files were used for further analysis in python, and different exported images have been used for visual analysis and illustrative purposes.

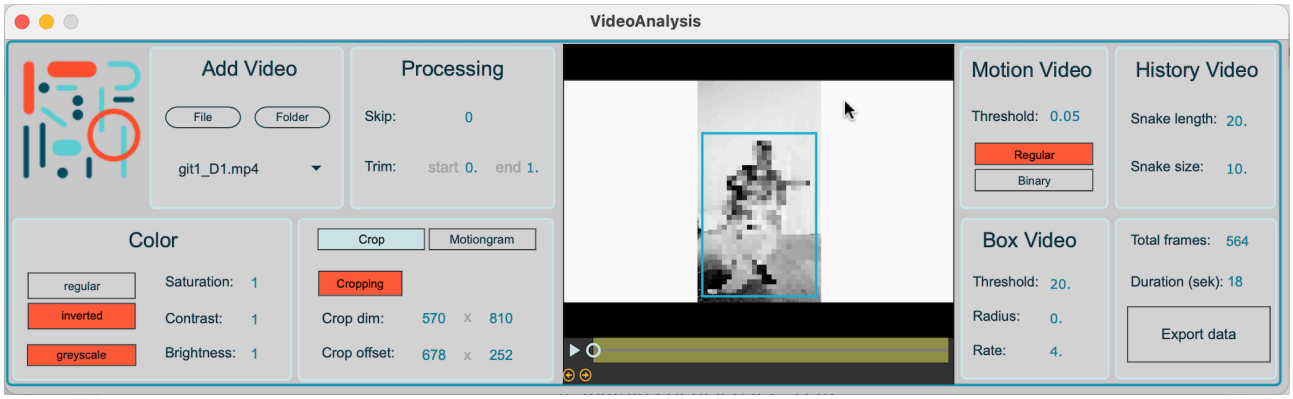


Fig. 6: Settings used for all video clips. The crop size differed according to where the guitarist and his movement were in the picture. Image of the video showing the guitarist has been pixelated for anonymization.

### 2.3.2 Analysis – audio

In addition to audio analysis using librosa I also used an experimental method where I wanted to visualize differences between different recordings, between all the dry recordings with either dry or wet monitoring, and between all wet recordings with either monitoring.

First the audio files where edited to correct length in Logic Pro X and the 16 audio excerpts of 18.8 seconds were, eight dry and eight wet.

Spectrograms can be created in multiple ways using different techniques. I chose Sonic Visualiser (Cannam et al. 2010) because of its easy user interface showing an immediate effect of parameter changes being made. In addition it is easy to compare multiple files in one session. I used default settings[14] for all parameters (fig. 7) simply because my aim was to mainly to acquire an image representing the sonic content of all excerpts, before starting the comparison.

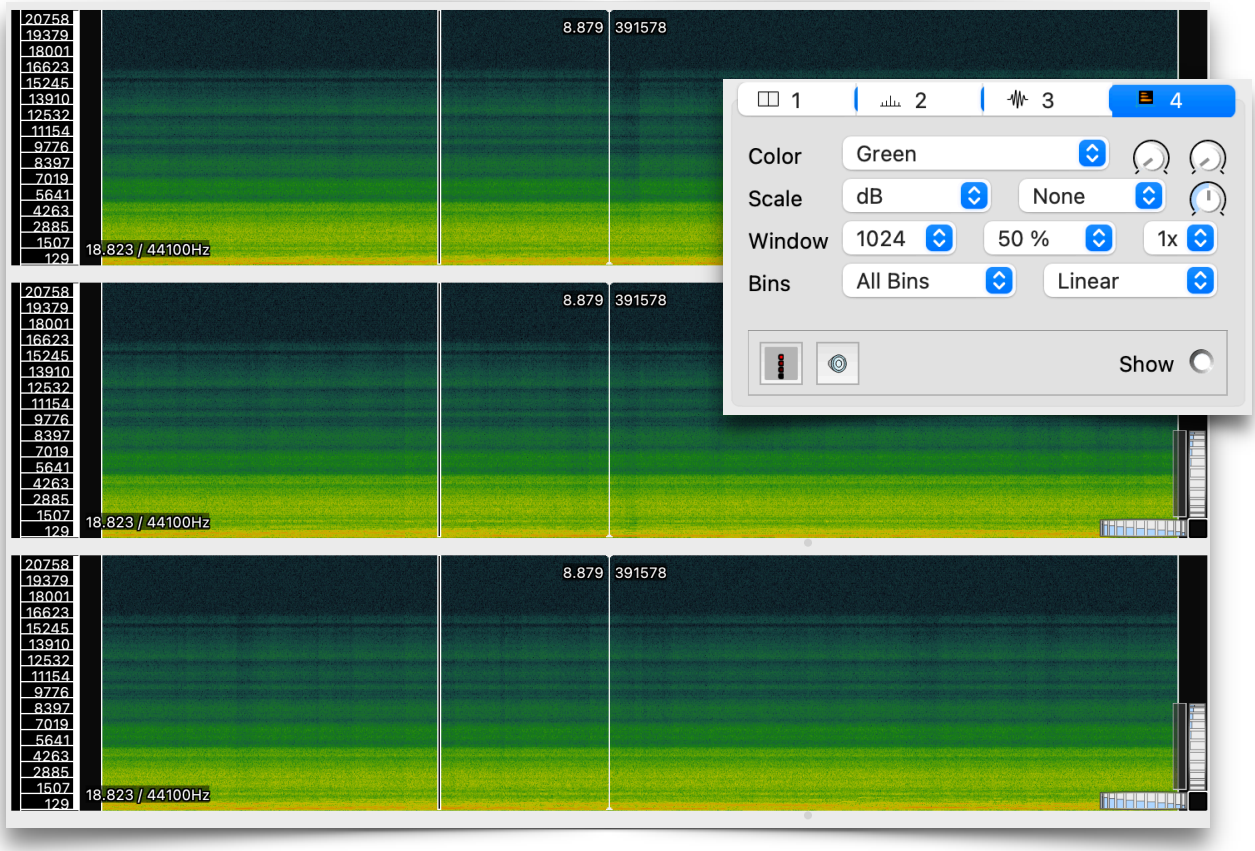


Fig. 7: Screenshot of three spectrograms for different wet recordings. Same settings are the same for all creation of spectrograms in Sonic Visualiser.

After creating spectrograms of all excerpts of guitarist 1's recording, I opened them in Pixelmator—a powerful image editor—and copied all spectrogram of the dry recordings into one file, each in their own layer, and the same for the wet recordings. Pixelmator offers a layer blending option called «Difference», which in essence calculates the difference between a pixel's color in the effective layer towards the adjacent pixel's color in the next visible layer below, and returns the result as black if it is the same or a new RGB-colored pixel. I did this with all possible couple couplings of the eight dry, and eight wet recordings accordingly and created new *combined and compared spectrograms*.

[14] See https://www.sonicvisualiser.org/doc/reference/4.5/en/#spectrogram for full documentation.

Using the formula for binominal coefficient where $n$ = 8 and $k$ = 2 gives a total of 28 different combinations each for the dry recordings and the wet recordings when comparing two:

$$\binom{n}{k} = \frac{n!}{k!(n-k)!} = \frac{8!}{2!(8-2)!} = \frac{8!}{2!6!} = \frac{8 \cdot 7}{2} = \underline{\underline{28}}$$

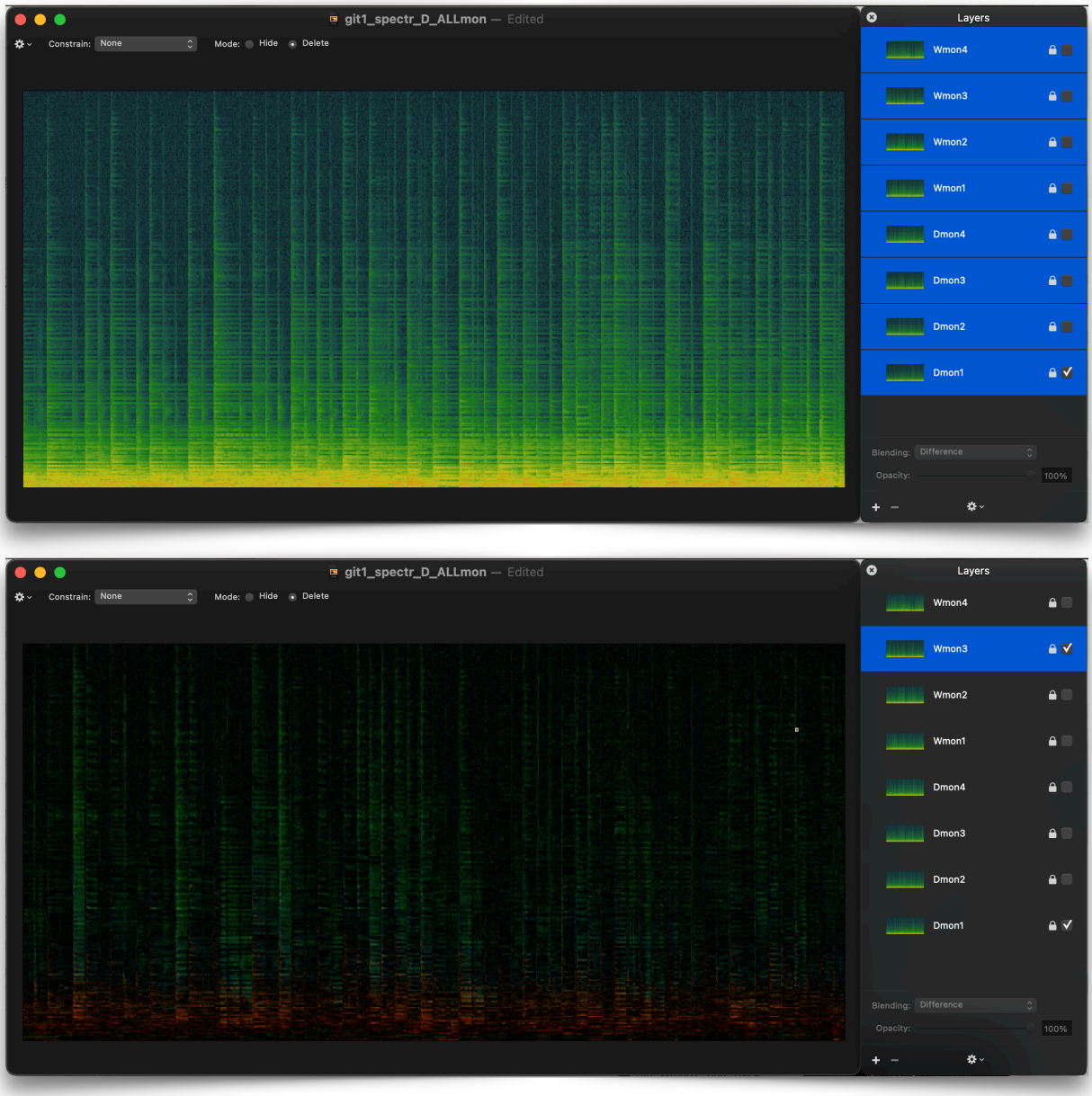


Fig. 8 and 9: Spectrograms of all eight dry sound recordings (guitarist 1, [NORM]) imported and layered in Pixelmator. Blending set to “Difference”, before two and two layers are made visible at a time, to export the «combined and compared spectrograms», as seen in fig. 9.

These new combined and compared spectrograms where then bitmapped, using a threshold of 9%, a value that creates a black/white image that in my view visually compares to the RGB-image. A threshold of 8% were deemed to be to dark and 10% to bright compared to the original combined and compared spectrogram.

The new black/white version of the combined and compared spectrograms (fig. 10) now showed a white pixel where there was a change in the audio, according to my parameter settings. The amount of white pixels where calculated in each of these images, using a simple python-script, and the values were then transferred to a Numbers-document (fig. 23) for further comparison, which showed comparable data over the—with my chosen settings—difference in audio (read as the combined and compared bitmapped spectrograms) for all monitoring situations.

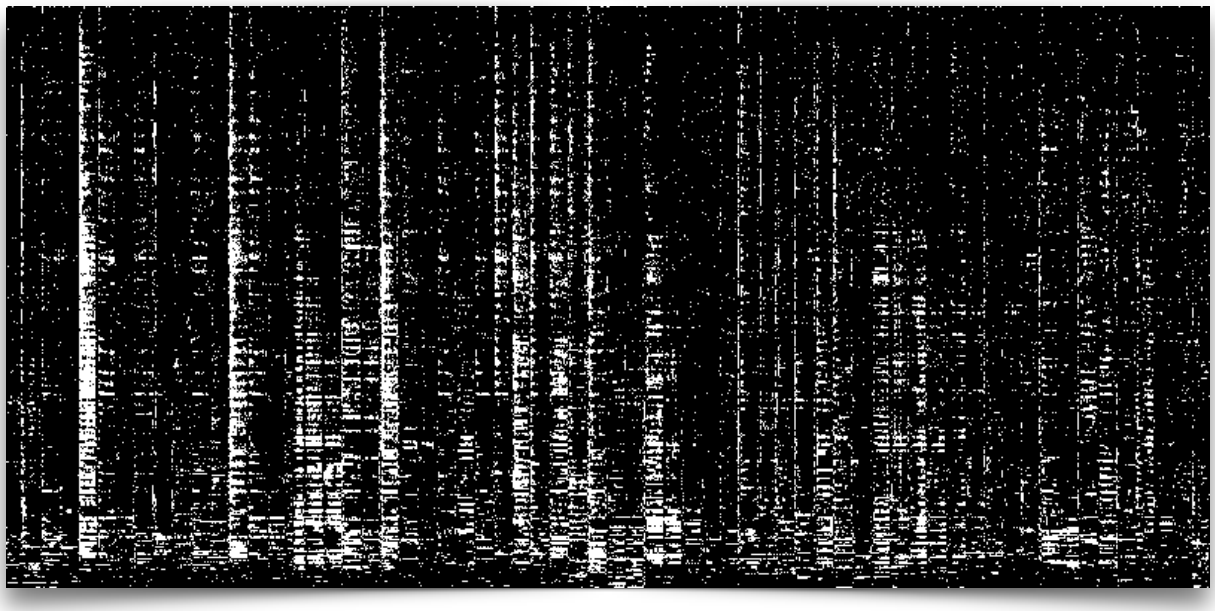

Fig. 10: Bitmapped version of the combined and compared spectrogram shown in fig. 8.

# 3 Results

In this section I will mainly present data and results from the second experiment, due to better data as a result of a better and more streamlined experiment. The results will be presented by graphs, illustrations, tables and diagrams.

## 3.1 Results – experiment 1

Despite deciding to use the first experiment as a pilot, I will present an interesting finding from it, which triggered the design of the final experiment. The first figure (fig. 11) shows the quantity of motion (QOM) over time in three takes, one when monitoring the wet re-amped signal, and two monitoring the DI signal, without any effects.

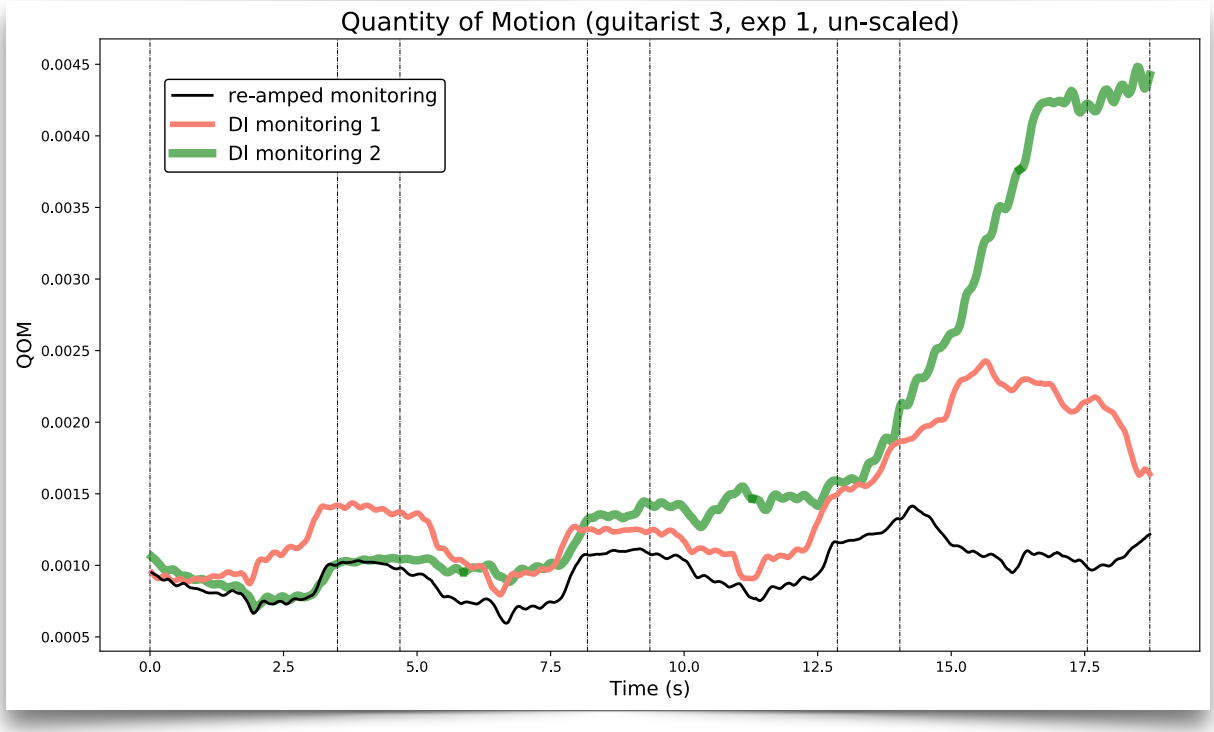


Fig. 11: Guitarist 3 [FX], participated in both experiments. The lineplots show a significant larger amount of motion in the two dry-monitored (DI) takes, than the wet (re-amped) take.The vertical dotted lines represent the chord-shifts. Since the green line in particular could be mistaken for a source of error, it is important to note that this also is an eight bar long excerpt, from the middle of a 16-bar part made out of two eight bar repetitions, just like in the newt experiment, as shown in fig. 4.

Next figure (fig. 12) shows a scatterplot created by using librosa. It is the same recordings, but instead of body motion, this represents the audio recorded in Logic. The dry recordings were chosen due to no compression of the signal. The wet (re-amped) signal is heavily compressed from both a TC Electronics Forcefield compressor as well as the other stompboxes in use in this particular take (especially the two drives in the chain, see footnote 9 in section 2.1.1).

The guitarist in this case clearly expressed the lack of comfort when monitoring the dry signal and said «it was terrible, it felt like playing a bad acoustic out of tune with no sustain». The tremolo (or whammy bar) was used a lot—Kevin Shields style—and he had to «try to imagine how the wet signal could be» when not hearing it.

Experiment 1 turned into being defined as my pilot as it gave me a lot of things to sort out. But even considering the—in my opinion—lack of consistency, the experiment really brought interesting findings to the table, and made me want to refine it and further explore the matters.

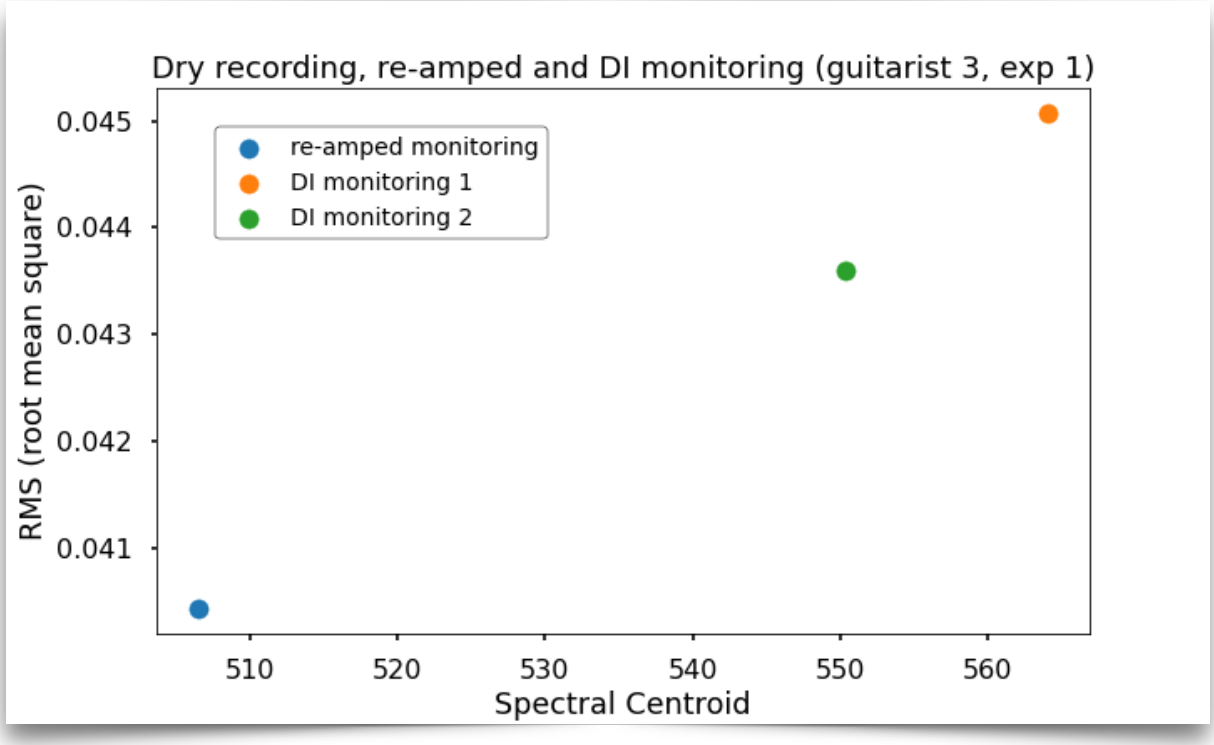


Fig. 12: Three dry recordings analysed by the energy (RMS) over the sounds "brightness" (spectral centroid). Even though the values are small, there is a significant difference in the character of both the dry-monitored (DI) signal, as opposed the wet-monitored (re-amped).

## 3.2 Results – experiment 2 – video

For the final experiment I will not present all the results in the form of images, diagrams and lineplots as it do not seem to serve the cause. I will present a representative selection of my findings, and if applicable I will present opposing results.

### 3.2.1 Results – experiment 2 – Quantity of Motion

I analyzed all video clips in VideoAnalysis as described earlier. Using python and matplot.lib I created normalized lineplots representing the guitarists quantity of motion (QOM) for all 32 video clips. I have chosen to present each guitarist with two QOM-

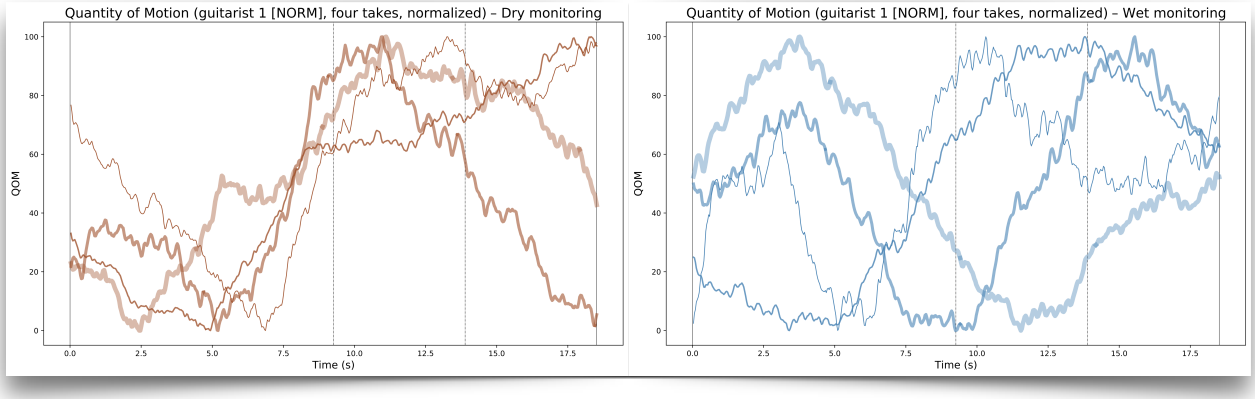


Fig. 13: Guitarist 1 [NORM]. Vertical dotted lines shows places of chord changes. Line thickness determines order within each plot, from thinnest (first take) to thickest (last take). Order of monitoring: DWDWDWWD

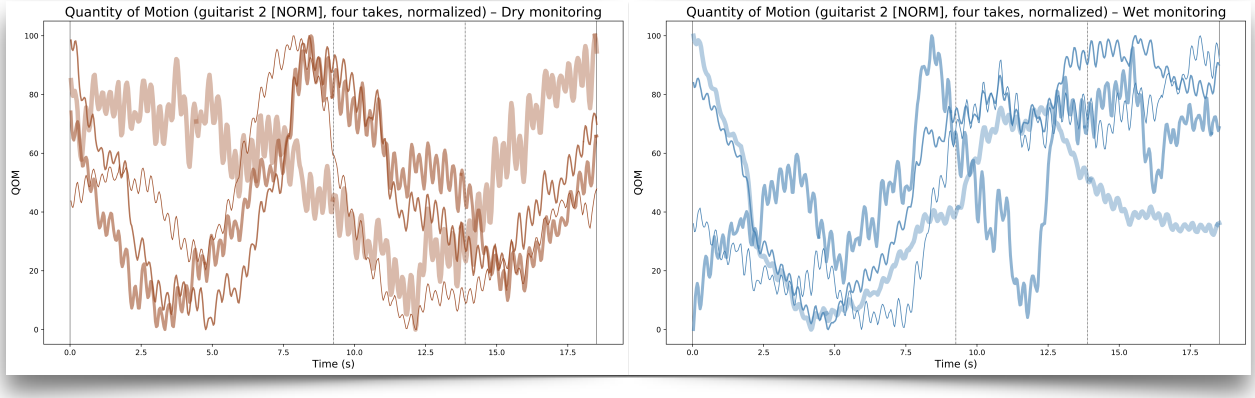


Fig. 14: Guitarist 2 [NORM]. Order of monitoring: WWDDWWDD

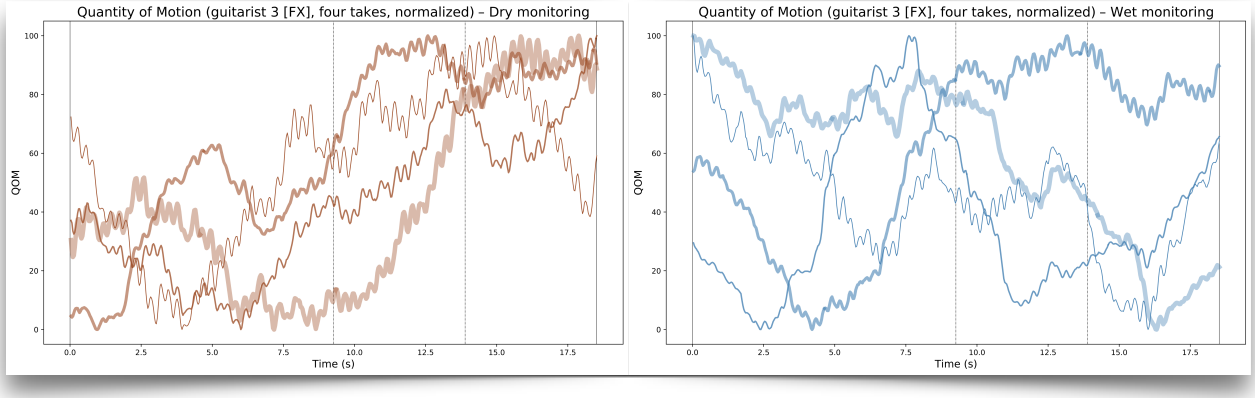


Fig. 15: Guitarist 3 [FX]. Order of monitoring: DDWDDWWW

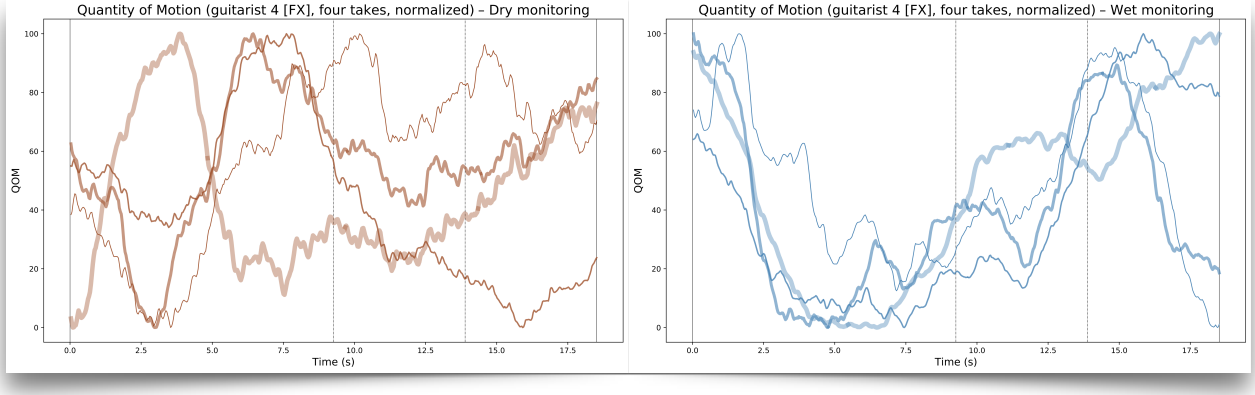


Fig. 16: Guitarist 4 [FX]. Order of monitoring: WDDWDDWW

lineplots, one for the wet monitored and one for the dry monitored (fig. 13 – 16). All figures show body movements during monitoring the dry signal on the left, and the wet signal on the right.

It would surely surprise me if the plots where the almost identical for body motions when monitoring  dry or wet respectively, but it is easy to spot trends among all four participants. Fig. 12 and 13 shows the two guitarists in the [NORM] category, and it shows that their body motions while monitoring the dry signal is quite comparable within their four takes. The last dry-monitored take for guitarist 2, shows more deviation, but other than that the amount of movements follows a pattern. One could assume that this pattern would show through the whole recording, but when monitoring wet signals, there seems to be more variation in the amount of movement.

Guitarist 4 (fig. 15), in the [FX] category, shows the opposite, and shows a pattern when monitoring the wet signal, and more variation when monitoring the dry, whereas guitarist 3 [FX] tend to follow a pattern in both situation, although looser when wet-monitoring than in the case of dry-monitoring.

### 3.2.2 Results – experiment 2 – motiongrams

Motiongrams is a visual display showing motion over time in either the x-axis or the y-axis , created «by collapsing video frames into 1 pixel wide matrices which are plotted against time. The resulting images display the level and location of motion in the video, and makes it easy to follow trajectories over time.» (Jensenius 2006). These images can be hard to interpret for a viewer unfamiliar with them, and also original video, but I will start by showing an example (fig. 17) with explanations.

Due to anonymizational purposes the motion-average image was used, and could preferably be replaced with a joint motion-average and first/last picture, showing a clearer image of the scene. But when knowing this is a guitar player, one can easily spot the light grey blurred head, the grey gitarneck, obviously moving up and down a little, and the very dark hand, showing where the most movements are happening, as expected when strumming a guitar. The darker the area, in both the motion-average image and the motiongrams, the more movement.

In these motiongrams the (red) strumming hand is showing up/down movements in the chopped and dark area in the x-motiongram, and while the more straight and dark hand-area in the y-motiongram shows some movement sideways, it is less obvious than in the x-motiongram, telling us the motions of the hand is more up/down, than side to side.

The head (green) shows up/down movements as well, most visible in the x-motiongram, and also a kind of sideways head-displacement lasting over a longer time-stretch, responsible for the mountain-like—or bottom of an ocean—visual representation.

The guitar head (blue) is harder to interpret, as it is totally covered by the strumming hand in the x-motiongram, but the motion-average picture tells more about the movements of the whole guitar neck and head.

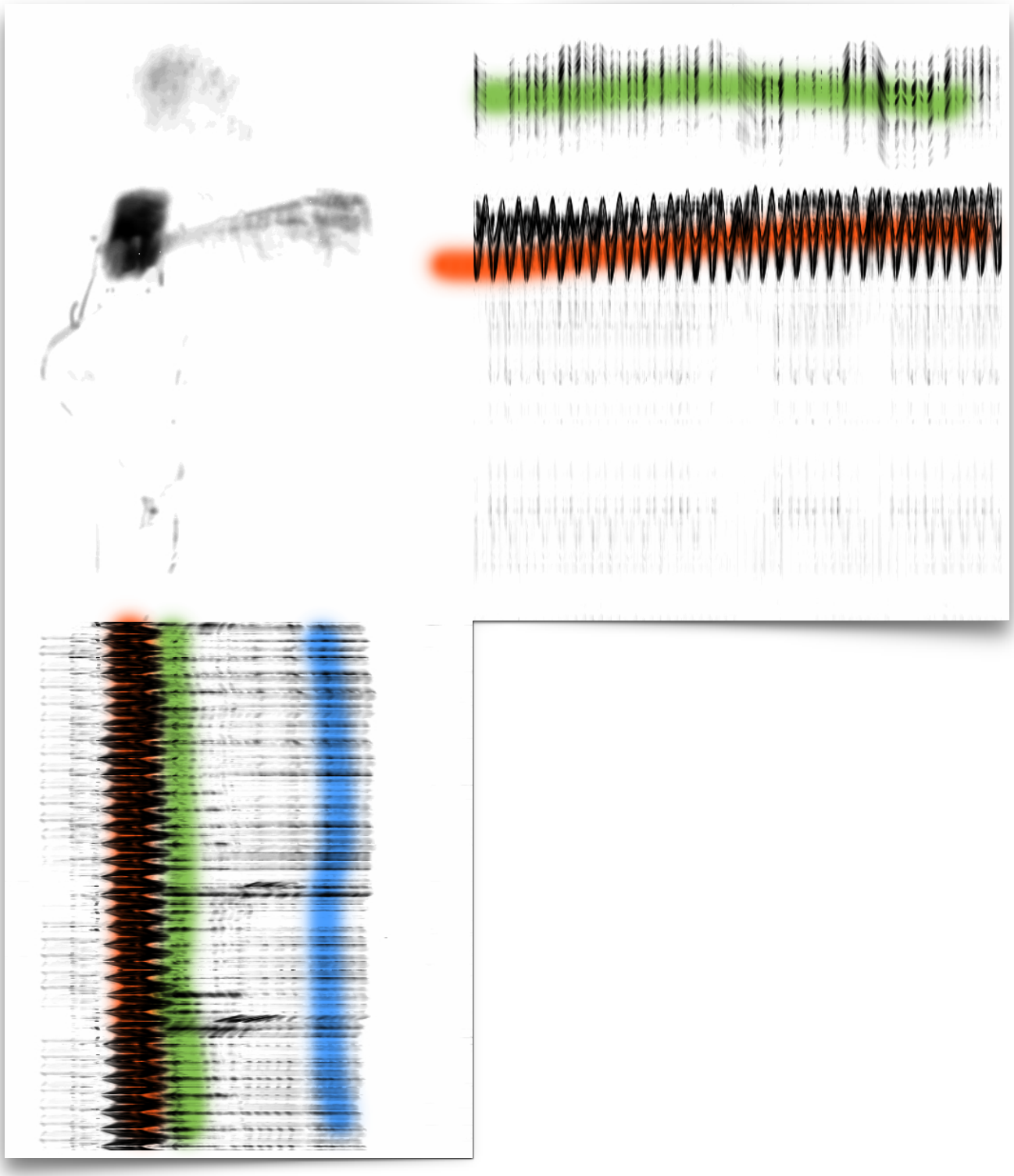

Fig. 17: X and Y motiongram of guitarist 2 [NORM] in the study. Figure shows a combination of a motion-average image (top left), a x-axis motiongram (top right) and an y-axis motiongram (bottom left). Red markings represents the area of the strumming hand, green marks the head, and blue the head of the guitar.

To illustrate how one can quickly read and compare motiongrams, I have placed all eight y-motiongrams for guitarist 4 [FK] together in one figure (fig. 18) showing body movements when monitoring the dry signal in the left column, and the wet signal in the right. The motiongrams in each column have more in common internally than with any motiongram in the opposite column, suggesting that the movements can be related to the monitoring situation.

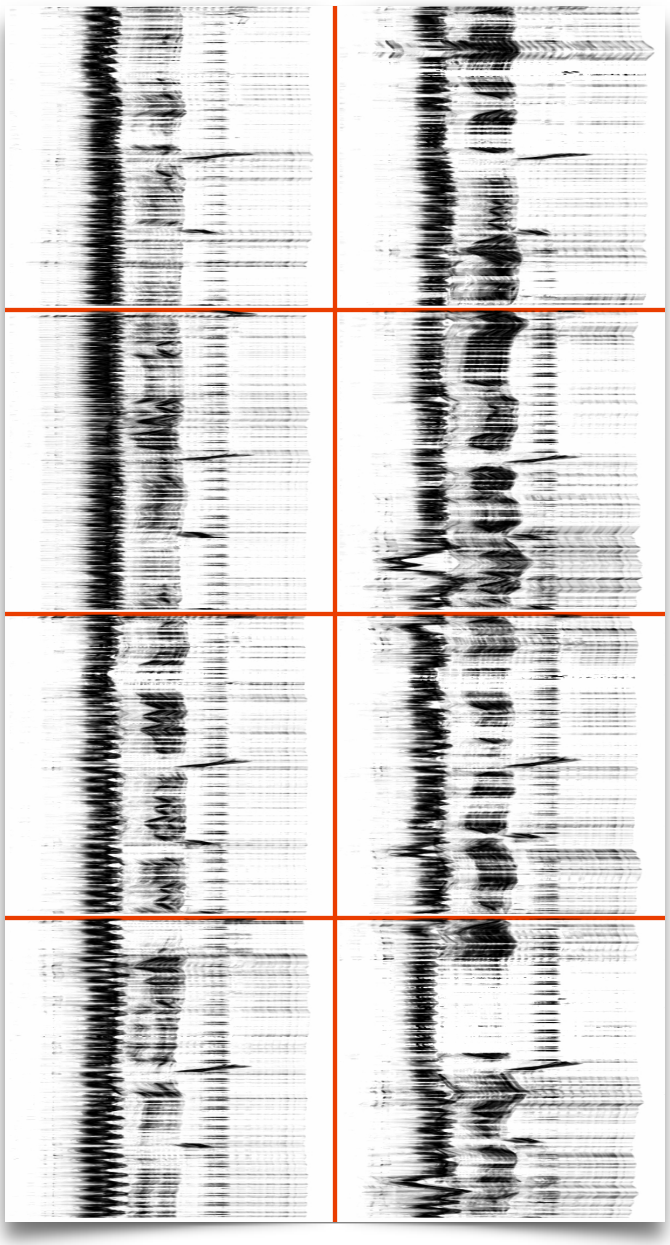

Fig. 18: Guitarist 4 [FX]. Y-motiongrams. Left column contains data from the four dry monitored video clips, and right column from the four wet monitored.

But when looking at the same kind of illustration (fig. 19) for guitarist 1 [NORM] it is harder to reveal any significant difference by visual inspection of the motiongrams alone, suggesting that his body movements may not be affected by the monitoring. It is obvious his body moves more evenly to the beat throughout the recording, judging by the more even distribution of curved lines and dark areas. When setting the eight motiongrams in the right order, as they were played, the illustration (fig. 20) might suggest some kind of development over the recording session. But one have to bear in mind that these motiongrams only cover half of the recording (64 bars out of 128), so there is a gap of 18.8 seconds where the red lines are.

Looking back at the QOM-lineplots (fig. 13), on the other hand, reveals that there is development in the amount of body motion within each of the almost 19 second long clips. And that there is a strong correlation between the dry monitored recordings especially, and also a debatable correlation among the wet monitored recordings.

The x-motiongrams (not shown) have been inspected, but are not giving any more obvious data. This only shows some of the complexity in retrieving data from registered body motion.

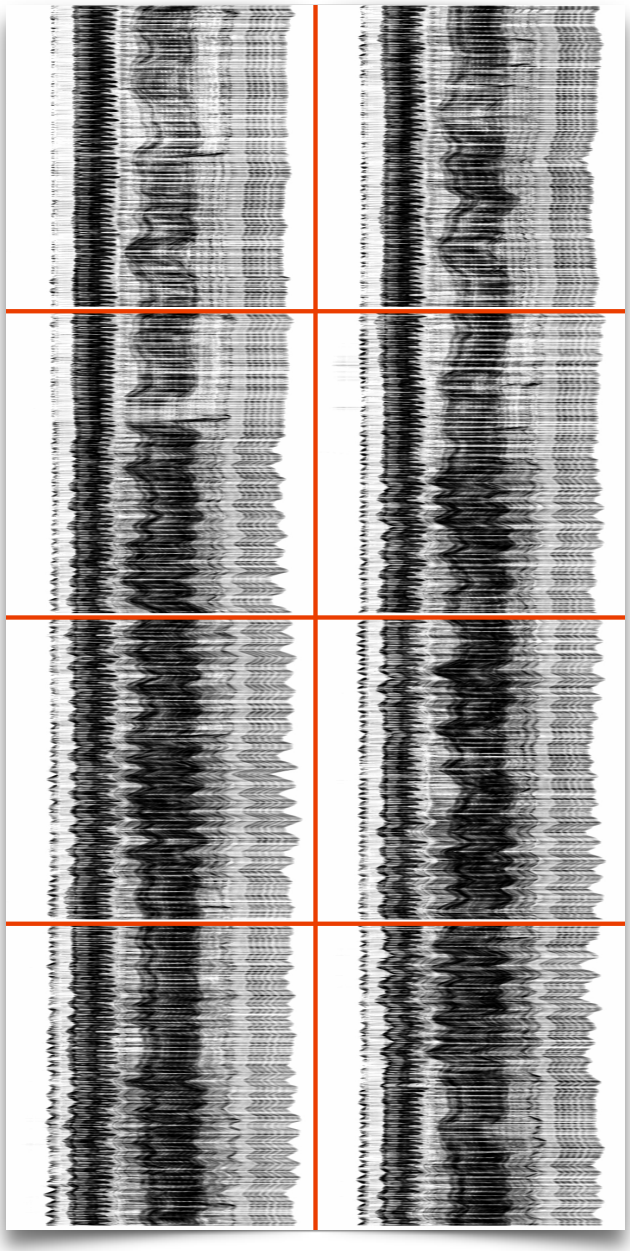

Fig. 19: Guitarist 1 [NORM] shows less or no visible difference in body movements when switching from dry to wet monitoring. Left column is dry monitored.

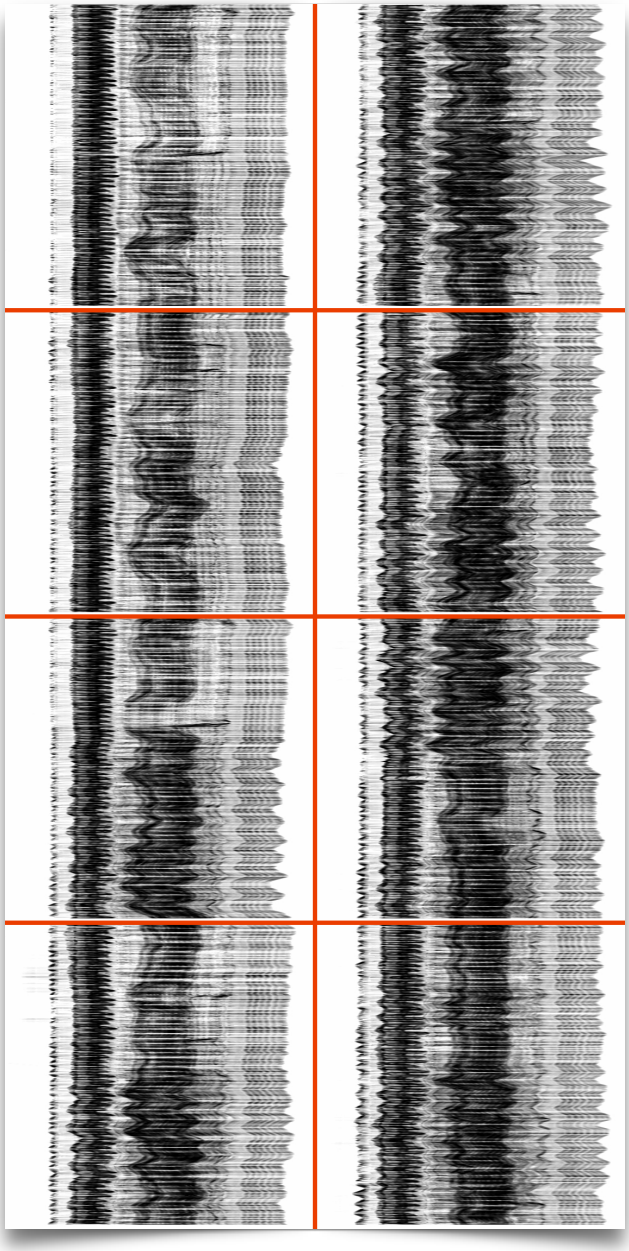

Fig. 20: Guitarist 1 [NORM]. Motiongrams displayed in the order they were recorded, from top left and down, over to top right and down. (DWDWDWWD)

## 3.3 Results – experiment 2 – audio

When it comes to music, the audio is obviously what matters most, so also in this experiment. But audio preferences are highly subjective (which is why I have been discussing re-amping and post-processing to the extent I have), and what works in someones ears, may or may not work for me. When analyzing audio it is important to know a little about the quality of the sounds we are analyzing. For instance, as I will work with, the more effects added to a (electric guitar) signal—or the more compressed and distorted it gets—the harder it is to differentiate two comparable audio files from each other, both by ear, but also by computer analysis. And comparing the same recording, but as a clean direct signal, will not compare to the wet signal, sound-wise. But using librosa and my experimental way of treating spectrograms reveals a story nevertheless.

### 3.3.1 Results – experiment 2 – librosa

Analyzing the audiofiles with librosa also reveals how each guitarist's playing is consistent within each monitoring situation, suggesting the guitarist's perception of the sound he creates in turn affects his playing to a degree where the sonic result is audibly different. If it is noticeably different is of course another story, but as this scatterplot showing RMS over spectral centroid for both the wet (labelled AMP) and the dry (labelled DI) recorded signal reveals, the amplified (or in this case amp & cab-

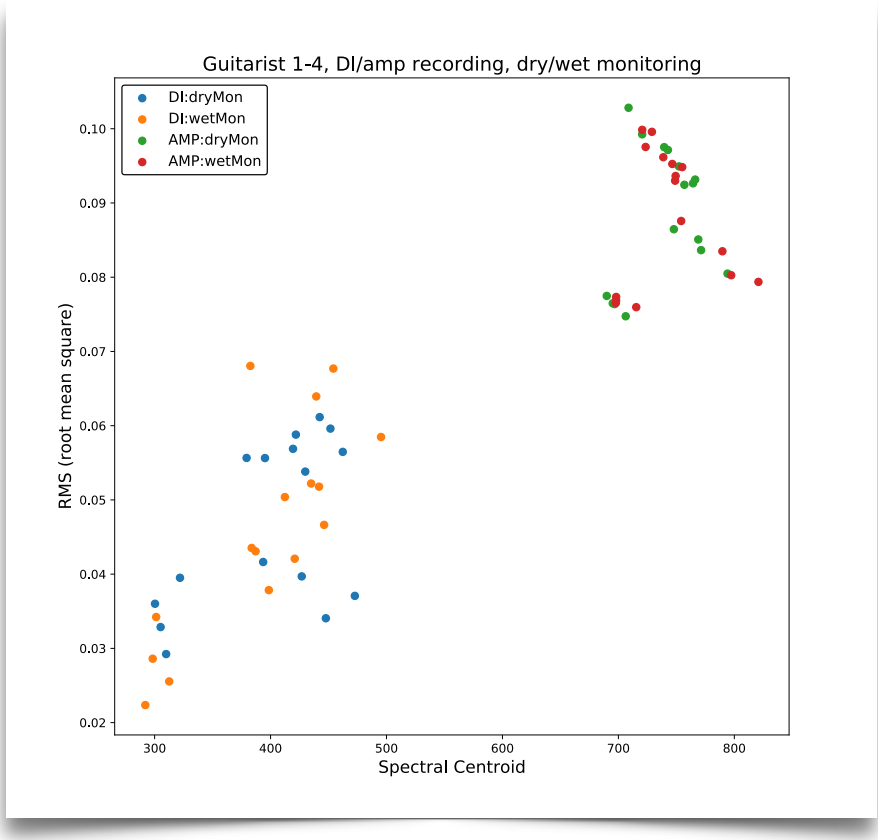


Fig. 21: Scatterplot showing a significant division between the recorded audio, the DI (blue and orange) and the amp (in reality cab-sim) signal, which contains the effects pedals chain as well (see fig. 3).

simulated) and effect-drenched wet signal is perceived as brighter, and also a has more energy. As pointed out earlier (fig. 12) this should come as no surprise, but what might surprise is when comparing fig. 21 with fig. 22; the same scatterplot, now showing the individual participants:

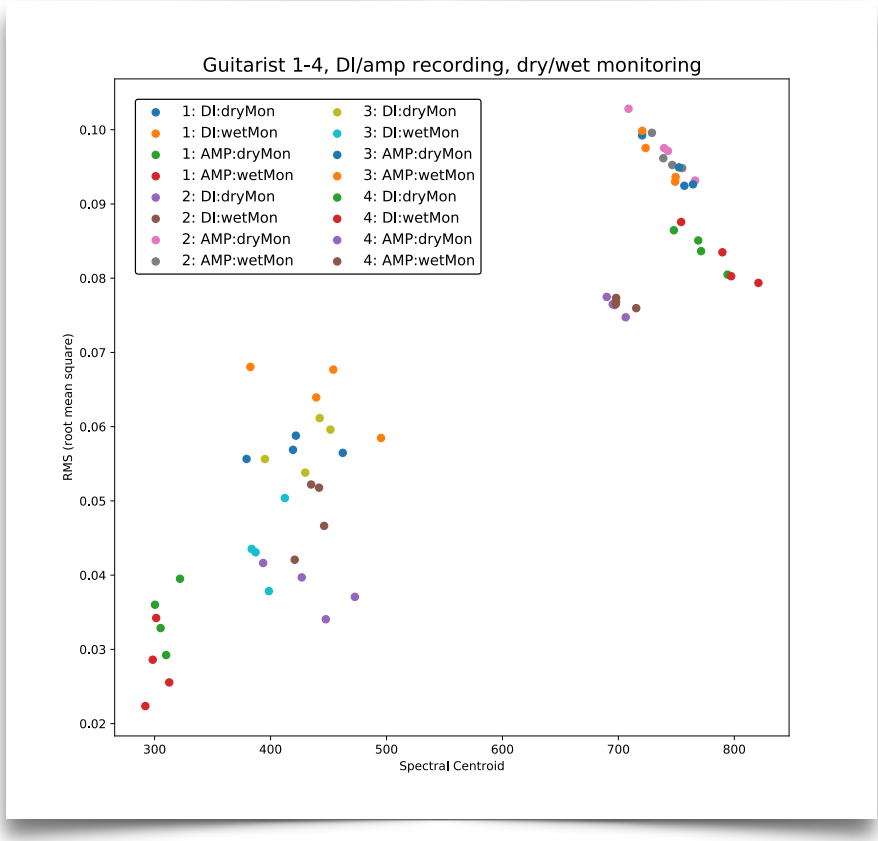


Fig. 22: Scatterplot showing each guitarist's (1-4) audio recording, both dry and wet signal.

When comparing fig. 22 with fig. 21, it reveals how for instance guitarist 1 [NORM] (orange and dark blue dots around 400-500 on the x-axis) plays harder when monitoring the wet signal (orange dots) than when monitoring the dry signal (dark blue dots). It is not as obvious when looking at the red and green dots around 750-830 on the same axis, representing his wet-signal. One can still draw a thin line separating these as well.

The same goes for guitarist 2 (purple and brown dots around 400-500 on the x-axis), interestingly also in the [NORM] category. Guitarist 3 [FX] and 4 [FX] trends towards the opposite, playing softer when monitoring the wet signal, guitarist 4 represented by the lower red and green dots in the left corner, the reds being the wet-monitored signal. It should be noted that due to guitarist 4 playing the J Mascis Jazzmaster in Berlin—as mentioned earlier—the dots representing those recording are more separate from the other, because of other pickups, electronics, and types of wood used, some would argue.

### 3.3.2 Results – experiment 2 – compared spectrogram

The results of the experimental method creating the black/white combined and compared spectrograms for a table (fig. 23) shows the internal differences between the audio, measured as white pixels in the compared spectrograms. The first columns list what kind of monitoring is compared, where «Dmon1 vs Dmon2» is short for «Dry monitoring, take 1 vs Dry-monitoring, take 2». The second column represent the dry recordings, and their corresponding spectrograms, and shows the amount of white pixels in the black/white combined and compared spectrograms (in the first row Dmon1 and Dmon2 is compared), an in the first row, the difference is calculated to 7.016 %.

The next column shows the same, but for the wet recordings, which have a lot less difference, according to these numbers.

What we can read out of this diagram, by taking a quick look at the mean difference, is that when comparing two recordings—no matter if it is a dry or a wet signal—both recorded when monitored dry, the difference in the audio between them is lower than if we compare two recordings with different monitoring (one dry, one wet), which again is lower than when comparing two recordings monitored wet.

Standard deviation show the same trend, and again this goes for both the dry recordings and the wet recordings.

**Audio differences between two dry or two wet signals, in regards to the monitoring situations.**

Dry sound and Wet sound, difference as %, are the percentage of white pixels, i.e. the pixels that differs within the 9% threshold between the two spectrograms compared.

| Monitoring | | Dry sound, difference as % | Wet sound, difference as % |
|---|---|---|---|
| D | Dmon1 vs Dmon2 | 7,016 | 1,422 |
| R | Dmon1 vs Dmon3 | 7,990 | 1,379 |
| Y | Dmon1 vs Dmon4 | 10,063 | 1,481 |
| | Dmon2 vs Dmon3 | 7,247 | 1,458 |
| vs | Dmon2 vs Dmon4 | 9,686 | 1,515 |
| | Dmon3 vs Dmon4 | 9,924 | 1,427 |
| D | Mean | 8,654 | 1,447 |
| R | Standard deviation | 1,398 | 0,048 |
| Y | Varians | 1,953 | 0,002 |
| | Dmon1 vs Wmon1 | 11,466 | 1,601 |
| | Dmon1 vs Wmon2 | 10,598 | 1,465 |
| | Dmon1 vs Wmon3 | 10,995 | 1,447 |
| | Dmon1 vs Wmon4 | 11,471 | 1,431 |
| | Dmon2 vs Wmon1 | 10,092 | 1,570 |
| D | Dmon2 vs Wmon2 | 9,682 | 1,522 |
| R | Dmon2 vs Wmon3 | 11,849 | 1,539 |
| Y | Dmon2 vs Wmon4 | 11,811 | 1,505 |
| | Dmon3 vs Wmon1 | 11,073 | 1,599 |
| vs | Dmon3 vs Wmon2 | 7,708 | 1,424 |
| | Dmon3 vs Wmon3 | 11,686 | 1,406 |
| W | Dmon3 vs Wmon4 | 10,316 | 1,511 |
| E | Dmon4 vs Wmon1 | 10,880 | 1,670 |
| T | Dmon4 vs Wmon2 | 10,229 | 1,539 |
| | Dmon4 vs Wmon3 | 16,312 | 1,569 |
| | Dmon4 vs Wmon4 | 12,450 | 1,540 |
| | Mean | 11,164 | 1,521 |
| | Standard deviation | 1,767 | 0,073 |
| | Varians | 3,121 | 0,005 |
| W | Wmon1 vs Wmon2 | 10,106 | 1,684 |
| E | Wmon1 vs Wmon3 | 16,792 | 1,725 |
| T | Wmon1 vs Wmon4 | 11,699 | 1,619 |
| | Wmon2 vs Wmon3 | 12,042 | 1,523 |
| vs | Wmon2 vs Wmon4 | 11,358 | 1,539 |
| | Wmon3 vs Wmon4 | 14,661 | 1,526 |
| W | Mean | 12,776 | 1,603 |
| E | Standard deviation | 2,470 | 0,087 |
| T | Varians | 6,103 | 0,008 |

Fig. 23: An experimental way of sound analysis, using coupled spectrograms for comparison.

# 4 Discussion

I started these explorations believing I would find some kind of altered playing when changing the monitoring, even when working with professional and semi-professional guitarists. It is likely that they might adapt to most any situation and do their job, without anyone but themselves noticing some conditions is not optimal. All experienced guitarists have played under very varied and different conditions, only by moving out of the rehearsal space to the recording studio or the live stage, even by just changing the location of the amplifier in the rehearsal room, makes the sound reflect in other ways, possibly causing the sound to be very different than before. So an altered monitoring is something they are very used to.

In the first experiment, two of the guitarists chose to leave their pedalboards behind, and use mine instead. And the third participant chose to leave his guitar at home, instead bringing his stompboxes. If it was a gig, they would almost always bring their own equipment (except for the amp, for two of them, at least) and showing up to the experiment with only a guitar or a pedalboard, could be interpreted as them not taking it to serious. I rather believe that it shows how professionals are used to adapt to different situation, and still do their job. At least one week before the experiment they were informed about all equipment they could borrow and use for the experiment, and one of the reasons it took for ages, was the gear discussions, as they all tried out my guitar and pedals.

What I learned in this first experiment was how hard it is to design and execute a proper experiment like this, that is as close to the real world as possible, but still scientific enough to acquire useful data from. I spent a long time planning and designing this, and discussing it with my studio-owning friends and other musicians, and with my supervisor. I thought I had most of it figured out, but the data I retrieved (and the data that was missing) was, as described in section 2.1.2, frustratingly inconsistent thus also inconclusive.

On the other hand, the experiment clearly showed that the monitoring affects both body motion and sonic outcome. In the most extreme case, when one of the participants played a chord progression using a lot of saucy effects with heavy modulation added, he felt «liberated» to subtly use the guitar's tremolo in addition, making the guitar sound even more seasick and floating. This technique, often referred to as 'glide' guitar—a signature of Kevin Shields of My Bloody Valentine—only works with an offset-type guitar with the floating tremolo. Listen to e.g. MBV's *Slow* or *Thorn*, or Slowdive's *Alison* to get the idea of how it sounds. When removing the reverb-drenched wet signal, this technique only leaves a detuned electric guitar, and the participant's body motions changed significantly, sometimes he even laughed out loud, a typical situation one would —in a real recording session—stop and start over again.

To execute an experiment like this requires good planning, and in my case I also needed to get back to my drawing board and refine it, before executing version two.

## 4.1 Expressivity

When nothing surprising happens, soundwise—especially in a live situation—and everything goes well, one can tell it only by watching musicians play; when they e.g. close their eyes, look up (or down), when they live the music. Dahl, drawing on Poggi, states that «[b]ody gestures and facial expressions are also used to help the pianist control the sound level» (Dahl et al. 2010, p 54), which I'd argue could be said for the guitarist as well. Even when there are lots of effects added to the signal, making it more compressed and less dynamic (loudness-wise), the musicians bodily and facial expressions also tells the listeners what they are intended to hear, as well as the character of the effected sound will change—maybe not in terms of loudness—when playing soft as opposed to hard. When using a distortion as an effect, a high gain effect that is «designed to rattle teeth and add sustain while preserving clarity and bottom end» (Bjørn, Harper 2019, p 112), the sound is normally highly compressed and even sounding. It is commonly used in metal genres (Herbst) for the recognizable heaviness in the sound, and—opposed to an overdrive or a fuzz—it is not designed to clean up, when playing softer or lowering the volume of the guitar. As described by Bjørn «[s]ofter playing remains up-front and loud, but the sound of the distortion can change dramatically from note to note» (ibid, p 114). I will argue that a typical distortion is one of the least expressive guitar effects, and when guitarists need something similar, they normally would get an overdrive (a versatile overdrive—the Fulltone OCD— was even used for distortion in Herbst 2018) or a fuzz. But even the typical distortion guitarist's expresses themselves through this un-expressive effect.

When, on the other hand, the sound perceived by the performer is out his/hers control, if a metal guitarist suddenly had gotten the Boss Metal Zone swapped mid-solo with an Electro-Harmonix Big Muff, a fuzz pedal with a totally different character and response to the playing, he/she would for sure have to alter the playing, to still preserve as much of the feeling and musical expression as possible.

### 4.1.2 [NORM] vs [FX] and expressivity

Two broad categories of electric guitarists were created, based on questions and conversations with the performers, namely the [NORM] and the [FX] categories. These categories matched up with the intensity they played with, where the [FX] guitarists played softer when monitoring a wet signal, and harder when monitoring the DI signal, and opposite for the [NORM] category. I can assume that the [FX] players are more used to express their musicality when using guitar effects, and the harder playing can be a result of them trying to compensate for the added dynamics (or to them sometimes awkward lack of sustain and compression) in the sound. Another theory could be their familiarity with the wet signal, making them relaxe more when playing then the [NORM] players, who again might try to add more dynamics to the heavily compressed sound they hear.

By looking at the motiongrams (fig.17 – 20) and QOM-lineplots (fig. 13 – 16) it is tempting to also suggest that the [NORM] players are more rhythmically involved with their body than the [FX] players, regardless of monitoring situation. The [FX] category

might be said to have a more floating or ethereal body motion, but mostly when monitoring wet signal, judging by the figures.

## 4.2 Limitations

A research like this has its limitations. First, the amount of data from four guitarists is not enough for a statistical significance, making possible conclusions more like assumptions. Even data pointing clearly in a direction, like the experimental method using two spectrograms to calculate a difference in audio files, is namely that, too experimental and un-tested to draw conclusions from.

The final and refined experiment was executed very well, but as the double gigbag were moved to different locations, and even though all settings were marked (fig. 24), there is no way to be sure that the conditions are the exact same for the participants. And while removing the amp from the experiment was necessary to be able to execute it properly, it takes away some of the joy of experimenting with electric guitars and related gear, and joy—or the abscence of it—is also very likely to contribute to altered playing.

As far as I know, nothing has been written about exactly this topic, and even though many studies touch upon the use of effects and other equipment, I have not found any literature trying to combine these ideas of how ones perception manifests in the physical body motion again leading to altered or adapted guitar performance. This of course makes the road a little longer and more bumpy, but also rewarding, I might add.

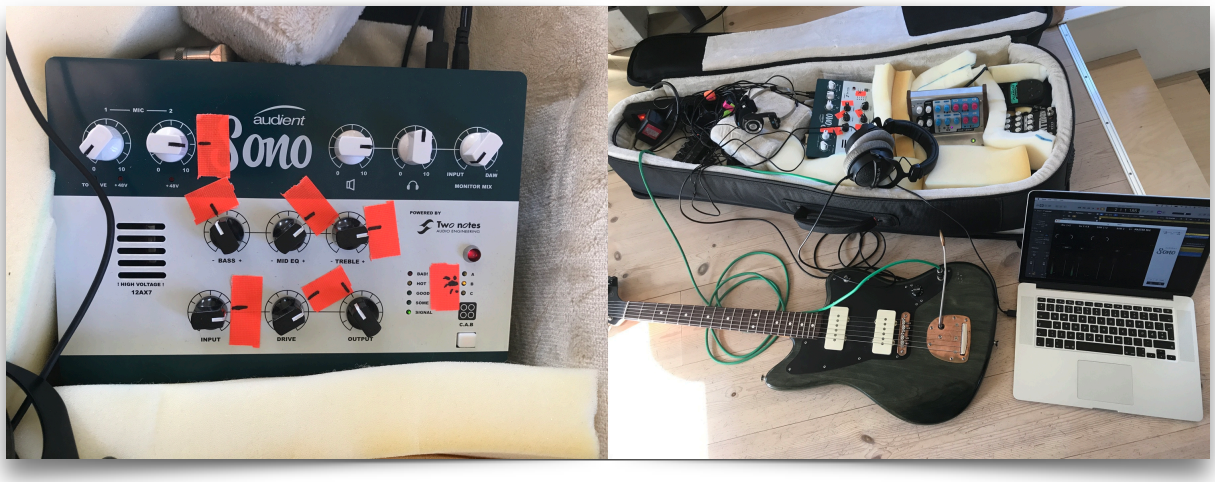


Fig. 24: Left: Parameter settings thoroughly marked. Right: Portable experiment lab.

## 4.3 Future work

And I would like to see this work continue. The experiment has been streamlined to a great efficiency, and the data gathered is of good quality, and can easily be performed in a much bigger scale. It would be very interesting to gather more data for comparison,

and possibly be able to conclude more firmly. To me personally, the most interesting and intriguing part of the project, has been to show the effect of different monitoring situations: that it actually matters, and how something might get lost on the way to the tape or hard drive, when not letting the musicians in control over their monitoring. I argue that most guitar performances will differ—not always in a noticeable way just by listening, but nevertheless they will differ—depending on what equipment is in use, as well as the content and quality of the monitoring. This is something producers, technicians and musicians should be aware of. So I will encourage anyone interested in the matter, to not only start doing more scientific research on it, but also start writing popular music articles about it.

A great deal of research on body motion and musical gestures has been done at UiO/ Ritmo in Oslo, and with experts also in the field of motion capture and related systems, this could be expanded with a continuous research on the bodily reactions a musician experiences when monitoring is not optimal. To be able to conclude that a guitarist's performance is being altered by the monitoring is one thing, next step could be to figure out *how* the guitar performance changes. I have shown that two of my participants plays softer when monitoring a wet signal, whereas the two other plays harder in the same situation. They were interestingly placed in matching categories, but I can only make assumptions (as I have already done in section 4.2) to why this is.

I would also be interesting to try to expand this to live performances, to design experiments even closer to the real world.

## 4.4 Conclusion

Even though the amount of data gathered in this interdisciplinary project is of no significant size, originating from only four different guitarists, some preliminary conclusions can be drawn because of the comparability and correlation in the data between the participants. I have shown, with a nicely designed experiment and following analysis of acquired data, that changes in the monitoring situation alters an electric guitarist's performance, and these findings are useful for musicians, producers, studio technicians, and also for researchers interested in music, motion and expressivity.

I can think of many reason why scholars have avoided studies like this. Firstly, if such a situation with monitoring is not self-experienced, one might not know about it, and even if one have heard about it, it is hard to imagine how it may affect the guitarist. As Waksman stated; scholars tend to exclude most musical practice before the recording session, (Waksman 2003, p 253) in other words they tend to wait until there is something easily measurable at hand. Secondly this is a domain where academics traditionally have not frequented, it is a place where the creative underground experiment and share their own un-scholarly research with likeminded. If mixing these two worlds—which we should—it would turn into a conjunction of two very different approaches to life, two separate languages, which rises the threshold even higher. I hope that with my two feets planted in the creative underground—and a hand trying to reach the academic world—I can contribute in bringing these worlds together.

*When musicians—amateur or professional—engage with the instruments they have chosen to play, they also engage with the techniques, the gestures, the sounds, and the meanings to which the instrument has given rise. The features and the possibilities surrounding any given instrument are limited, but are never entirely predetermined either by the material dimensions of the instrument itself or by the social strictures regarding its use. As with popular music itself, musical instruments can be used to reinforce dominant modes of social organization or to confront them, to reinscribe dominant social relations, or to open new alternatives. Yet I would go one step further: musical instruments are arguably the most fundamental constituent elements of music, and as such contain the largest potential for reorchestrating the practice of musical performance and production, or for ensuring that musicians and audiences do not deviate too far from established norms.*

(Waksman 2003, p 257)

# 5 Bibliography


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