/medien & digitale technologien

/fh/// st.pölten

Live drums
vs.
MIDI based drum replacement

Is there still an audible difference for laywomen/men?

Research Paper

Bachelor course on Media Technology
at St. Pölten University of Applied Sciences

by:
Thomas Maislinger
MT-161125

Supervising tutor: Dipl. Ing. FH – Prof. Andreas Büchele

[St. Pölten, 26.06.2019]

Declaration

- The attached research paper is my own, original work undertaken in partial fulfillment of my degree.

- I have made no use of sources, materials or assistance other than those which habe been openly and fully acknowledged in the text. If any part of another person's work has been quoted, this either appears in inverted commas or (if beyond a few lines) is indented.

- Any direct quotation or source of ideas has been identified in the text by author, date, and page number(s) immediately after such an item, and full details are provided in a reference list at the end of the text.

- I understand that any breach of the fair practice regulations may result in a mark of zero for this research paper and that it could also involve other repercussions.

.....	.....
Place, Date	Signature

Abstract

This thesis analyses the question if there still exists an audible difference between a live-recorded drum set and a sample-based drum replacement for laywomen and laymen.

The goal and motivation behind writing this thesis is to find out if financing a professional drum recording is necessary for a modern music production. Not only because of the economic aspect, but also, in a lot of cases, it represents the most time-consuming part for recording engineers in a music production.

Table of contents

Declaration 1

Abstract 2

Table of contents 3

1 Introduction 5

2 Recording acoustic drums 7

2.1 Choosing your weapons 7

2.1.1 Instrument 8

2.1.2 Microphones 10

2.1.3 Room acoustics 14

2.1.4 Setting up the microphones 14

2.1.5 Routing and digitalization 15

3 Mixing drums 16

3.1 Stereo panorama 16

3.1.1 Panning drums 18

3.2 Genre 19

4 Digital Drums 20

4.1 Samples 20

4.1.1 MIDI 20

4.1.2 Synthesizers and Samplers 21

4.1.3 Sample libraries and players 22

4.2 Drum replacement 23

4.2.1 Tools for drum replacement 24

4.3 NI Studio Drummer 25

5 Empirical study 26

5.1 Hardware 27

5.1.1 Drum-Set 27

5.1.2 Microphones 29

5.1.3 AD conversion and outboard gear 31

5.2 Rooms 32

5.2.1 Measurements Soundschmiede 32

5.2.2 Room – Native Instruments' Studio Drummer 34

5.3 Recording 35

5.3.1 Portrait of the drummer 35

5.3.2 Grooves 36

5.4 Post production 37
5.4.1 Converting to MIDI and back to audio 37
5.4.2 Mixing 39
5.5 Survey 43
5.5.1 Target Group 44
5.5.2 Listening conditions 44
5.5.3 Questionnaire 45
5.6 Testing phase 51
5.6.1 Participants 51
5.7 Evaluation 52
5.7.1 Summary 52
5.7.2 Individual Evaluation 57
6 Conclusion 63
References 64
List of figures 67
List of tables 70
List of listings 71

1 Introduction

The problem that a lot of home studio owners or producers still have, is that if they record MIDI based tracks at home, they are nearly never satisfied with how the drums sound. After hours and hours of watching video tutorials and reading books about drum mixing it still won't give them the result they are looking for. (Senior, 2011)

The excuse you read and hear the most in online audio technic forums is that it is because sample-based drums, programmed or replaced, just cannot deliver the same emotional impact that self-recorded drums can. On the other hand, top engineers like Ryan Hewitt, Andrew Sheps, Deadmau5 and a few others claim that with professional recorded drums as well as with any other sampled based instruments, it only matters "What comes out of the speakers". (Sheps, 2018) Meaning that it actually doesn't matter how a piece of art is produced, as long as it feels right it feels right and so do MIDI drums.

Leaving the questions:

Is a piece of music better when the drums are self- recorded?

Does it make a difference to the audience?

Is the difference even recognized by the listener?

Based on the drum recording literature of Bobby Owsinski, Mike Major and a few other recording specialists, a simple, loopable rhythm has been recorded with a specific sample rate and bit depth. In order to be able to compare the replaced version to the self-recorded one, an algorithm has transfered the performance of the drummer into MIDI data using transients. Considering the virtual instrument/plug-in that was used on the programmed MIDI track, the hardware of the drum kit, the microphones as well as pre-amps and A/D converters were selected to match the conditions with which the samples were recorded (As good as possible. The gear that wasn't possible to rent, was mentioned and exchanged with some that has similar properties and characteristics).

Without any further digital processing the drum tracks were bounced (exported) as an interleaved stereo .wav file, matching the initial sample rate and bit depth of the samples within the virtual instrument.

The empirical part of this bachelor thesis contains those files, other melodic instrument loops, participants and a questionnaire for each of those participants.

Considering the assumption, that music listeners are rather listening to the finished product than to the drum tracks only, instrumental music was composed for the two different drum loops in order to imitate a whole song.

After listening to the two versions of the same groove, being the self-recorded and the programmed drum kit (with and without other instruments), the participants had to decide which of the versions were the self-recorded live drumkits and which the replaced ones.

The evaluation of the questionnaire then gave an assumption for possible answers to the question of this bachelor thesis.

2 Recording acoustic drums

This chapter contains all the information necessary to record an acoustic drumkit in a professional way. It covers everything needed for a solid drum recording concept that will achieve the musician's desired timbre. Starting with the choice and positioning of microphones, room acoustics, up to signal flow and recording into a DAW.

2.1 Choosing your weapons

To prepare an adequate drum recording session there are a lot of things to consider before even thinking about hitting the record button. A lot of engineers and producers agree with Ross Garfield, or as he calls himself and his business 'The Drum Doctor', on the fact that the first instance of great sounding drums on a record is the instrument itself. (Garfield, 2016; Owsinski, 2009)

The second instance would of course be the musician, but as this is an engineering-based thesis it was decided to skip this chapter and just conclude it by using the hypothesis, or in a lot of cases called rule or law, that a good drummer can deliver a good drum sound if properly recorded.(Garfield, 2016; Mistele, 2012; Owsinski, 2009)

Third comes the engineer with all his or her knowledge about microphone techniques, room acoustics and the understanding of turning sound into a discrete signal.(Garfield, 2016; Mistele, 2012; Owsinski, 2009)

2.1.1 Instrument

Figure 01: Parts of a drumkit (Maislinger, 2018)

A standard acoustic drumkit usually consists of a kick/bass and snare drum, were experts agree that these are the two main parts for the rhythm, usually two small hanging drums called toms and with that, a bigger one standing on the ground called the floor tom. As for the cymbals, the standard setup mostly consist of a hi-hat, a ride and a crash. (Izhaki, 2012; Mistele, 2012; Owsinski, 2009; Senior, 2011)

Most engineers and specialist agree that with serviced mechanics like the foot machines of kick drum and hi-hat, with which squeaking can be avoided, and new as well as tuned heads, you probably have a good base to start with. Ross Garfield thinks different. As the drum doctor claims that tuning itself is a science of its own, there is certainly much more to a nearly perfect instrument for a desired sound.(Garfield, 2016; Mistele, 2012; Owsinski, 2009)

Bobby Owsinski also writes about how powerful it can be to work with different materials for the instrument to achieve a certain type of sound. He wrote the following list of different drum materials and more properties of the kit, that in his opinion are important for the colour of the drum sound, in his book ‘The recording engineer's handbook’(Owsinski, 2009, p.112):

“

- **Shell size** has the most impact on the natural pitch of a drum. The larger the diameter, the lower the natural pitch, although you can obviously change this a bit by tuning the heads.
- **Shell depth** is mostly responsible for how loud the drum will be and, to some degree, the articulation of the sound. This means that a shallow shell (say a 9-inch tom) doesn’t have as much surface area as a larger one, so the sound is a bit shorter with a sharper attack.
- **Shell thickness** is usually overlooked as a contributing factor to the sound of a drum. Thinner shells actually are more resonant since they’re easier to excite because they have a lower mass than a heavier, thicker shell.
- **Shell material** used to make the drum shell is the most responsible for the tone of the drums. Here are the most commonly used drum shell materials:
    - Maple is the most prized construction material by drummers, primarily because the sound is so even across the drum frequency spectrum.
    - Mahogany sounds warmer than maple because the low end is increased.
    - Birch is very hard and dense, which results in a brighter drum with a lot less low end than maple.
    - Poplar has a sound very similar to birch, with a bright top end with less bottom.
    - Basswood exhibits an increased low end that’s similar to mahogany.
    - Luaan has a warmer sound with less top end, similar to mahogany.
- **Shell interior** has a lot to do with the pitch of the drum. A rough interior produces a less resonant drum, since the roughness breaks up the interior reflections. A smooth interior results in a more resonant drum, which means it’s easier to tune and control.
- **Bearing edges** refers to the cut at the edge of a drum shell where the hoops are attached. The way the bearing edge is cut can not only affect the pitch of the drum, but the tuning as well. The sharper the cut, the brighter the drum.
- **The type of hoop** and the number of lugs used to seat the drum heads determine how the drum will sound. In general, the thicker the hoop, the easier the drum will be to tune. Fewer lugs provide more complex overtones. Stamped hoops get a warmer tone than die-cast hoops. Aluminium gives a high pitch, while brass provides more overtones. Die-cast hoops are generally both thicker and stronger than stamped hoops, so the drum becomes easier to tune. There are fewer overtones as a byproduct.Wood hoops come in different thicknesses, so they can be made to sound like either a stamped or a cast hoop, only brighter.

“ (Owsinski, 2009, p.112)

List 01: List of properties coloring the sound of an acoustic drum kit (Owsinski, 2009)

2.1.2 Microphones

Andreas Mistele categorizes microphones in his book ‘getting pro’ in four different properties:

- **Receiver principle**
  - First step of converting acoustic into mechanical energy
    - Principle of pressure
      - Always omnidirectional

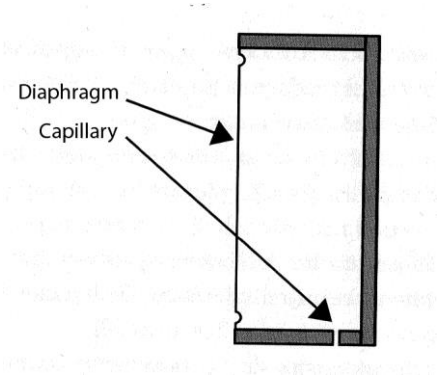

Figure 02: Principle of pressure (Mistele, 2012)

    - Principle of pressure gradient
      - Through ports other polar patterns possible

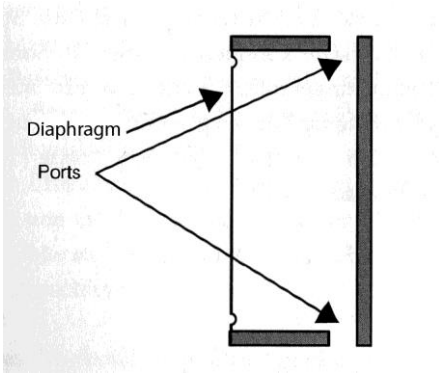

Figure 03: Principle of pressure gradient (Mistele, 2012)

(Mistele, 2012; Owsinski, 2009; Winer, 2012)

- **Converter principle**
  - Second step of signal processing
    - Dynamic Microphone
      - Is very robust and durable
        - Convenient for live shows

- Standard polar pattern is cardioid
- Best choice for handling high pressure levels
- Has emphasized frequencies (approx. 1 - 4 kHz)
- Less dynamic range than other microphones (Cutting of at approx. 10kHz in most cases)

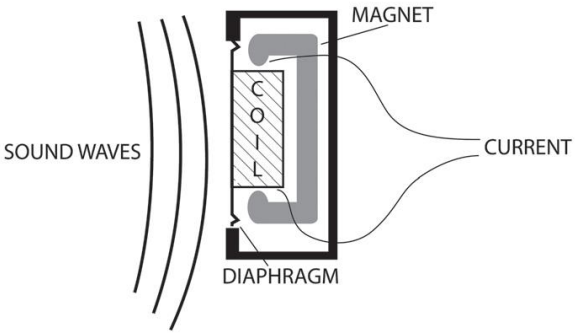

Figure 04: Dynamic microphone (Owsinski, 2009)

(Mistele, 2012; Owsinski, 2009; Winer, 2012)

- Condenser microphone
  - No other principle of conversion delivers such a wide dynamic range and linear frequency response
  - Fragile and expensive
  - Requires external powering (usually +48Volt = Phantompower)
  - Native state of pick up pattern is omnidirectional, but with specific holes punched in the backplate each common polar pattern is possible

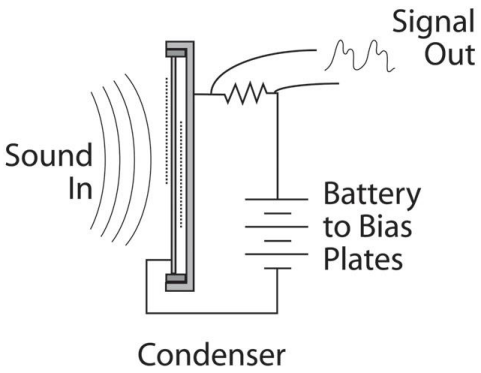

Figure 05: Condenser microphone (Owsinski, 2009)

(Mistele, 2012; Owsinski, 2009; Winer, 2012)

- Ribbon microphone
  - Dynamic or moving coil sibling of the dynamic microphone
    - Also called electro-dynamic
  - Because of less weighted diaphragm more dynamic range possible than with dynamic microphones
  - Very small electrical signal -> boost is necessary which leads to noise artefacts
  - Most fragile microphones
    - Too much sound pressure can destroy the diaphragm
      - Also, does dropping the microphone
  - Soft sound in high frequency areas
  - Usually figure of 8 polar pattern

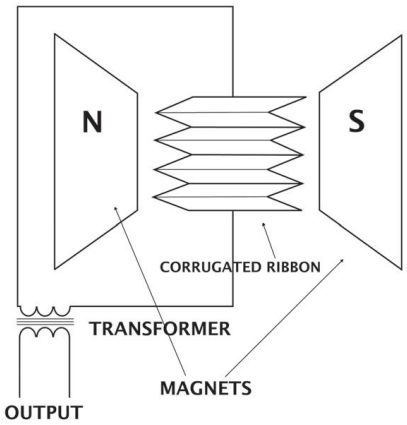

Figure 06: Ribbon microphone (Owsinski, 2009)

(Mistele, 2012; Owsinski, 2009; Winer, 2012)

- Other microphones
  - Boundary level microphones are sometimes used for recording bright attack hits of the kick drum
  - A piezo or a lavalier microphone as well as a few others are not really relevant for professional drum recording so I decided to leave further descriptions aside in order to set focus at the task at hand.

(Mistele, 2012; Owsinski, 2009; Winer, 2012)

- **Membrane size**
  - Large diaphragm
    - 18 – 34 mm
    - Enhanced low frequencies and room noise
    - Warmer sound than small diaphragm
  - Small diaphragm
    - 12 – 17 mm
    - because of less weight and size of the membrane a quicker response is possible which leads to a more detailed and brilliant recording

(Mistele, 2012; Owsinski, 2009; Winer, 2012)

List 02: List of different microphone types (Mistele, 2012; Owsinski, 2009; Winer, 2012)

- **Polar pattern**
  - "The directional response of a microphone is the way in which the microphone responds to sounds coming from different directions around it." (Owsinski, 2009, p.11)
  - "The directional response of a microphone is recorded on a polar diagram. This polar diagram shows the level of signal pickup (sometimes shown in decibels) from all angles and at different frequency ranges. It should be noted that all mics respond differently at different frequencies."(Owsinski, 2009, p.11)

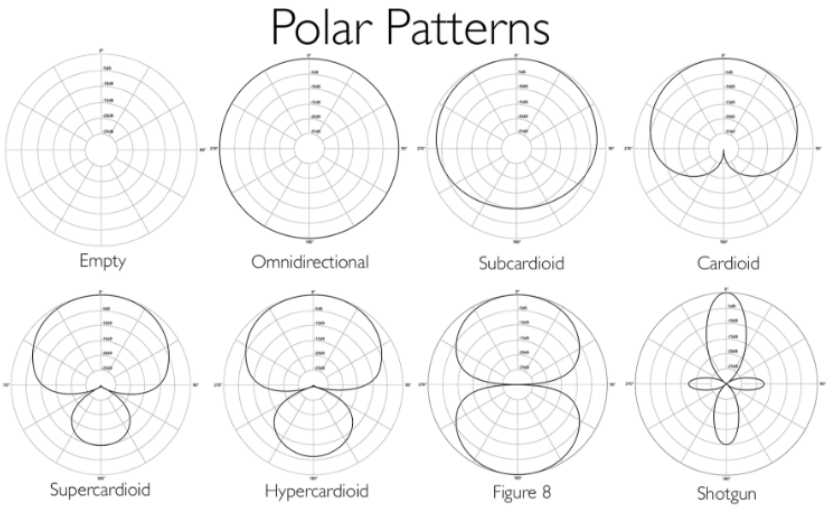

Figure 07: Common polar patters of microphones (Audio, 2018)

2.1.3 Room acoustics

The choice of the right room is one of the most important aspects decisions in each recording, despite which instrument or singer you choose to record, because it determines how sound waves are spreading, reflecting and shaping before reaching the microphone/s. As for drums, Andreas Mistele and Ethan Winer recommend that the room should be big and especially high. Around 4 to 5 m should provide enough security to avoid potential comb filtering effects and provide a transparent cymbal sound. The bigger and higher the room, the less acoustic diffusing components you need to achieve a big drum sound. He also writes about the fact that early reflections can really tighten up the entire kit and provide the snare drum with an explosive bang. (Mistele, 2012; Winer, 2012)

2.1.4 Setting up the microphones

Every engineer has his or her own secret drum recording set up when it comes to placing the microphones. In order to get an idea of which factors of positioning the microphones are colouring the sound most, based on the literature of this thesis a small list of these aspects has been created, rather than name the perfect recording set-up: (Görne, 2014; Mistele, 2012; Owsinski, 2009; Winer, 2012)

- Selection of microphones
    - Matching their characteristics and colouring effects
- Number of microphones
- Angle of the microphone in relation to the sound source
- Distance of the microphone to the sound source

List 03: List of positioning microphones based on (Görne, 2014; Mistele, 2012; Owsinski, 2009; Winer, 2012)

(Görne, 2014; Mistele, 2012; Owsinski, 2009; Winer, 2012)

2.1.5 Routing and digitalization

The typical signal flow is the same as with any other recording. Most microphones are connected via XLR cables to a preamp (or preamps) which then is or are connected to an analogue to digital converter (or converters) (there also exist combined hardware where the pre-amp/s and the a/d converter/s are built in one device) which then is or are connected to the computer. As for the pre-amps it is important to notice that the type and model of those amplifiers are colouring the sound of the incoming signal in a non-reversable way, so they should be selected with caution.(Mistele, 2012; Owsinski, 2009; Senior, 2011; Winer, 2012)

No matter which DAW (Digital Audio Workstation) is being used, it is recommended to create a separate drum recording session in order to maintain a clear structure throughout the whole project. Also, naming the tracks after the part of the instrument that is recorded in combination with the correct microphone set on the input of the tracks is recommended.(Izhaki, 2012; Owsinski, 2009, 2014; Savage, 2014; Senior, 2011)

3 Mixing drums

When it comes to mixing an acoustic drumkit, lots of renowned engineers claim that this is the part where professionals separate themselves from laywomen and laymen, especially when it comes to the rhythm section in total, meaning the relationship between the drums and the bass or as Bobby Owsinski calls it in his book
'The mixing engineers handbook':"The foundation" (Owsinski, 2014, chapter 5) of every mix. (Izhaki, 2012; Owsinski, 2014; Savage, 2014; Senior, 2011).

3.1 Stereo panorama

Before we get to the panoramic mixing task of a drum kit, the term panorama has to be defined first. Using two ears, the human brain differences via time, frequency and amplitude, the location of a sound source. Panorama is also called stereo image because it represents "[…]the imaginary space between the left and right speakers." (Izhaki, 2012, p.64)

Izhaki also defines four criteria of a stereo image in his book 'Mixing audio: concepts, practices and tools' as follows:

- Localization
- Stereo width
- Stereo focus
- Stereo spread

List 04: Criteria of a stereo image based on (Izhaki, 2012)

But why is it imaginary if it is clearly audible and locatable?

When stereo was invented in 1931 and a few years after became relevant in modern studios, engineers had the choice of only three parameters on their mixing

console. Left, centre and right, or as Bobby Owsinski calls it in his book 'The mixing engineer's handbook' "The Big Three" (Owsinski, 2014, chapter 6).

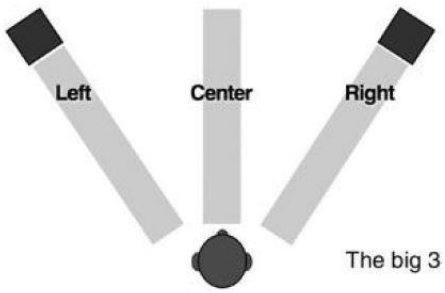

Figure 08: The big three panning areas (Owsinski, 2014)

The sound was either coming a hundred per cent from the left or right speaker and in case it was centred, from both sides simultaneously, resulting in the so-called phantom centre and the answer to the question. It is imaginary because in a stereo set up a centre speaker does not exist even though it is audible. That is because even in a perfectly measured speaker set up where the sound of each source arrives at the according or nearest ear because of distance and levels, it still arrives late on the other one resulting in a "slight smearing of the perceived sound image" (Izhaki, 2012, p.182).(Izhaki, 2012; Owsinski, 2014; Savage, 2014)

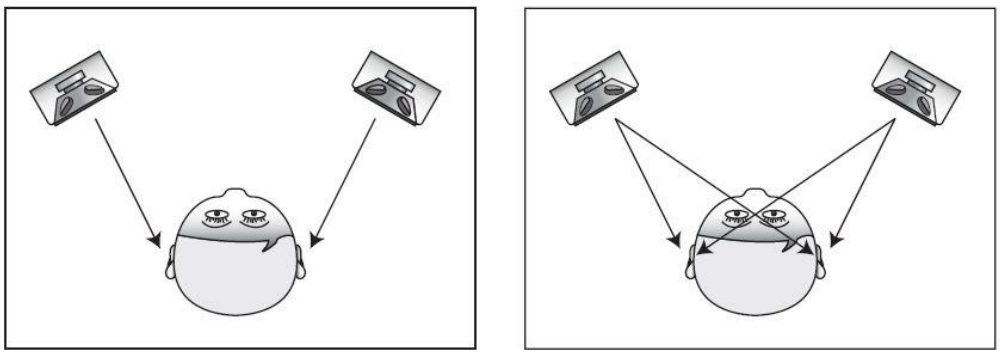

Figure 09: Stereo perception (Izhaki, 2012)

3.1.1 Panning drums

Modern panning differs a lot from the first built in stereo system in the Abbey Road Studios in London where only the three states (L-C-R) existed. Because of the awareness of phasing and other problems with hard panning (=100% left or right) this method nowadays is used very rarely and if so, rather for artistic and creative purposes than out of technical limits. Modern panoramic functions in DAWs or on mixing consoles are using a 180 degree stereo spectrum subdivided in numeric scales, mostly represented in percentages or hours. (Izhaki, 2012; Mistele, 2012; Owsinski, 2014; Savage, 2014; Senior, 2011)

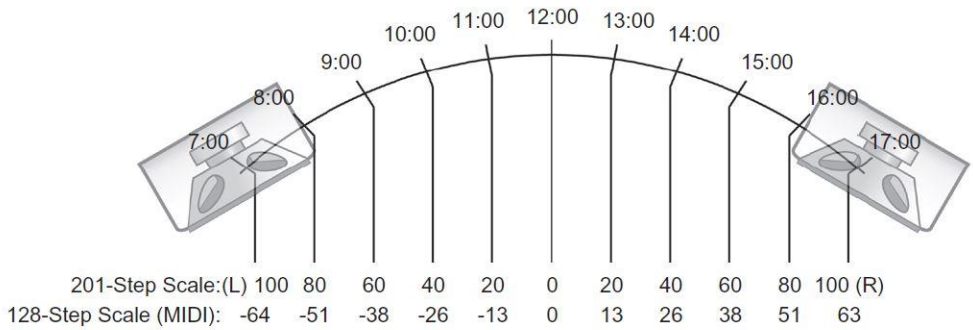

Figure 10: Position of the hours on a stereo panorama and the equivalent numeric values on the 201-step (Pro Tools, Cubase) and 128 – step (MIDI) scales. (Izhaki, 2012)

With parametric and numeric scale based panning technologies, new ways of binaural perception came along hand in hand. Especially for the drums. When it comes to panning drums, one aspect of the recipient that is manipulated most, like for any other multiple track instrument, is the perceived size of the kit. Engineers are not limited to mix either a huge or a small kit anymore. The size of the instrument, or rather how big it feels for the listener, can be adjusted individually

and way more precisely now.(Izhaki, 2012; Mistele, 2012; Owsinski, 2014; Savage, 2014; Senior, 2011)

The second aspect that has to be considered when panning drums is the point of view. It is rather a personal decision than a technical one to pan the parts of a drum kit from a drummer's or an audience's point of view. Either way it is recommended to maintain with that panning perspective for the whole band, orchestra etc. Usually the snare and the kick drum are placed in the centre because listeners expect them to be more present than other parts of the drum kit.(Izhaki, 2012; Mistele, 2012; Owsinski, 2014; Savage, 2014; Senior, 2011)

3.2 Genre

The drum sound should always fit to the characteristics expected by the listener. As already mentioned in this thesis the selection of the instrument, the technical hardware and the room have an enormous impact on how the recorded live set will sound in the end, but also does the post production. According to the genre, it is the mixing engineer's task to finalize and polish the sound the recording engineer and especially the artist or composer had in mind. For a modern sounding metal band for instance, the kick drum is normally cut quite short and has a lot of attack while missing out on the low end. Or when a mixing engineer is asked to shape the kick and snare to sound typically hip hop and the ride more jazzy, he or she has to listen to genre specific references to know what is wished for and how to achieve that by using external plug-ins and the tools available in the DAW during the post-production. Long story short, the purpose the drums are used for has a huge influence on the final sound when it comes to mixing and generally the post-production.(Mistele, 2012; Owsinski, 2014; Senior, 2011)

4 Digital Drums

With the enormous amount of sound libraries on the modern market, programming or even replacing recorded drums is a common tool that most professional engineers in the industry use nowadays.(Görne, 2014; Izhaki, 2012; Mistele, 2012; Shier, McNally, & Tzanetakis, 2017; Winer, 2012)

This chapter covers the basic information required for this workflow.

4.1 Samples

To avoid any confusion with the technical and the musical use of the word sample or sampling and to clarify in which way samples are needed for drum replacement, the variations of the usage are explained in the next two paragraphs:

The term ‘sample’, as in a short-recorded audio file of any sound source (mostly instruments) that can later be played back by using specific hard- or software, as it is mostly used is actually alienated from the technical origin of the word.(Winer, 2012)

Ethan Winer summons up the technical term quite accurate in his book ‘The Audio Expert: Everything You Need To Know About Audio’ as followed:

> “The process of converting an analog voltage to equivalent numbers is called digitalization, or sampling, and a device that does this is called an analog to digital converter, or A/D.”(Winer, 2012, p.233)

As we do not want to analyse the technical term further and avoid digging deeper into frequently memorized voltage states (analog to digital conversion), we rather talk about the musical aspect in order to get to know the tools we need for drum replacement.(Winer, 2012)

4.1.1 MIDI

By using hard- or software that support the musical instrument digital interface (MIDI), virtual instruments or synthesizers containing sound samples can be triggered and controlled. The MIDI protocol uses asynchronous transfer, meaning

that it does not exist a continuous data stream. Data is only transferred when a command is triggered via a controller. This data contains information about which note is played (pitch), how long and how hard that note is played and in case the controller is linked to a synthesizer, even the data about the type of instrument is delivered to the receiving station. The MIDI protocol can send and receive 128 different quantized states, filled with the musical information of the already mentioned dynamics and pitches. But it can also be used as 128 different brightness-states of headlights for instance. When the first synthesizers with MIDI integration became relevant they all had three different DIN ports. The MIDI IN port was for receiving MIDI messages, the MIDI OUT port was for sending MIDI messages to another device or an audio interface, and the MIDI THRU port was used to connect and use more devices at once.(Görne, 2014; Winer, 2012)

Figure 11: MIDI ports (Görne, 2014)

Nowadays the most MIDI devices you find out on the market use USB 2.0 or FireWire connection. (Görne, 2014; Winer, 2012)

4.1.2 Synthesizers and Samplers

What is the difference between a synthesizer and a sampler?

Hardware synthesizers are oscillators with certain effects and piano keys. A hardware sampler on the other hand looks quite familiar, but instead of manipulating sinus waves, it plays back pre-saved audio files that are stored on the onboard memory of the device using the MIDI protocol. With this technology, that is also called wavetable synthesis, a pianist is able to play each instrument he or she wants. Doesn't matter if it's a saxophone, a violin, or in our case a whole drumkit. (Izhaki, 2012; Mistele, 2012; Winer, 2012)

Because of price policies and the consistent increasing number of home studios, software samplers are often the preferred investment over the hardware section, even if lots of engineers still claim that hardware gear, up to this day, sound more natural. (Izhaki, 2012; Mistele, 2012; Winer, 2012)

4.1.3 Sample libraries and players

Those software samplers mentioned need content in order to be used as virtual instruments. This content mostly consists of wave files of either percussive or sustained instruments. Percussive instruments (drums, piano, guitar, etc.) are easier to create, because they decay naturally over time. They need no further editing, while for sustained instruments like a violin for instance, a digital simulated loop function has to be configured so the composer can decide how long a note is played. When creating sample libraries, one thing that has to be kept in mind is for which software player they are going to be produced. Kontact, SoundFont, Roland, AKAI and a lot of other sample player companies have their own codec and data structure of how samples are processed and triggered via MIDI hardware.(Izhaki, 2012; Winer, 2012)

When recording a whole band, a lot of engineers prefer to create their own drum samples of the actual recorded drum kit for safety reasons. It is always recommended to have a backup sample from each part of the kit, in each dynamic happening in the song, just in case something went wrong during the recording session without anyone noticing (hitting a microphone with a drumstick for example). The engineer then can easily replace the damaged part with a sample, which brings us to the next chapter. Drum replacement.(Izhaki, 2012; Mistele, 2012; Winer, 2012)

4.2 Drum replacement

Many times, bands pay a huge amount of money for drum recording sessions in professional studios with well-known drum specialists. Those specialists sometimes need up to a week only to prepare the drumkit itself that is then set-up perfectly in a separate drum recording room and recorded by renowned engineers only to be later replaced with samples in about 20 min. One band that is known by the whole world that already had this workflow in the 90s, was Nirvana with their song 'Smells like Teen Spirit'.(Garfield, 2016; Izhaki, 2012; Owsinski, 2009)

But why pay a lot of money and spend a lot of time on setting up microphones for a drumkit that later is going to be replaced anyway?

For once, the artists and especially the drummer will hear the difference of his or her own drum kit and a 100% digitally replaced one. And secondly, maybe not the whole drum kit has to be replaced in order to achieve the sound expected by the customers or the mixing engineer prefers to parallel mix the samples with the original sound.(Izhaki, 2012; Mistele, 2012; Owsinski, 2014; Savage, 2014)

Replacing drums is not always necessary, but a very useful tool to achieve that 'fat drum sound' that is so often asked for by clients. Before replacing the recorded drum tracks with samples, there are a few things to keep in mind: (Izhaki, 2012; Mistele, 2012; Owsinski, 2014; Savage, 2014; Shier et al., 2017; Winer, 2012)

- It is recommended to look for samples that match the root note of the song. (Tuning)
    - Especially when mixed with the original overhead-tracks things can get unpleasant very fast if that fact is not considered
- Checking phase alignments of the recorded source against the samples
- Ghost notes are hard to replace
- Professional produced drum samples are often pre-compressed
- Some tools for detecting transients work better than others
    - The simpler the groove the better the automatic replacement works

List 05: Considerations before replacing drums based on (Izhaki, 2012; Mistele, 2012; Owsinski, 2014; Savage, 2014; Shier et al., 2017; Winer, 2012)

4.2.1 Tools for drum replacement

One method of replacing drums with samples is with **drum module triggers**. Those devices are mounted onto each part of the drum kit and connected via a line signal to a specific interface where the hits are converted to MIDI notes and desired samples can be selected. This is the same technique used on modern e – drumkits. (Izhaki, 2012) “Most modules are velocity-sensitive, meaning that the triggered sample level corresponds to the level of the input hit.” (Izhaki, 2012; p.458)

Figure 12: Yamaha EAD10 Drum Module (Thomann, 2019)

As drum module triggering is something that is set up in a recording session were each member of the team agrees that the drums will be replaced anyway, there is no turning back to the original signal afterwards, if not also properly recorded, which is obsolete if the replacement decision has already been made beforehand. (Izhaki, 2012; Owsinski, 2014; Senior, 2011)

Another way to replace the drums, is the software-based solution inside the DAW or by using external drum replacement plug-ins. **Drum replacement plug-ins** are not only capable of real-time replacement but can also play back different samples for different input velocities, thus resulting in more haptic and realistic sounds. If on the other hand the engineers decide to replace or mix the original drum signals with samples during the mixing processes, because of personal taste or other factors, the **audio to MIDI** function is a very good option that is mostly a built-in standard in modern DAWs. When the wave forms are converted into MIDI notes, any desired samples or virtual instruments can be loaded onto them. (Izhaki, 2012)

4.3 NI Studio Drummer

The virtual instrument that has been selected for this thesis, to collect scientific and empirical gathered knowledge about whether laywomen and layman still hear a difference between a naturally recorded and a 100% sample-based MIDI drum kit, is ‘The Session Kit’ of Native Instrument’s ‘Studio Drummer’.

Figure 13: Studio Drummer Plug-In – The Session Kit (Native Instruments, 2019)

The Studio Drummer is a virtual instrument for the Native Instrument’s sampler ‘KONTAKT Player’ with over 3000 pre-recorded grooves that can be easily put into a session via the simple drag and drop function and it also has a huge library of samples of each part of the drum kit in many different velocities and styles. It consists of three different sounding type of kits (The Stadium Kit, The Session Kit and The Garage Kit) and has implemented functions for mixing, equalizing, compressing, saturation, convolution reverberation, etc. All the samples have been recorded via a SSL 9072J mixing console, a Millennia HV-308 preamp and a Fairchild 670 and a prism Sound MLA-2 compressor. (Native Instruments, 2019)

5 Empirical study

Figure 14: The recorded kit (Maislinger, 2018)

VS

Figure 15: Studio Drummer Plug-In –

The Session Kit (Native Instruments, 2019)

Based on the theoretical knowledge gathered through the research for this bachelor thesis and the necessary practical skills acquired at the university of applied science St. Pölten and an internship realized in the SteinHof and the Soundschmiede music production studios based in Vienna, an empirical scientific attempt was made, that should give a clearer image of whether laywomen and layman hear the difference between live drums and MIDI based sample – drums. The process of how this attempt was made is described in the following chapters.

5.1 Hardware

In order to achieve a result sounding as close as possible to the virtual instrument, the selected hardware for the live recording was orientated on the hardware index of the official Native Instruments Website (https://www.native-instruments.com/en/products/komplete/drums/studio-drummer/) and the subpage of the Session Kit of the Studio Drummer plug-In. Because of financial circumstances the used hardware is not 100% identical to the one of the 'Studio Drummer', but the technical characteristics of each part have been taken into account and attempted to match. To visualize the hardware differences a table for each category was created. (Native Instruments, 2019)

5.1.1 Drum-Set

The drum set of Native Instrument's 'The Session Kit' of the virtual instrument plug in 'Studio Drummer' consists a "Yamaha Maple Custom Absolute kit […]"(Native Instruments, 2019), with selected snare drums and cymbals.(Native Instruments, 2019)

The drum set recorded for comparison purposes of this thesis consists a Sonor AQ2 Maple Studio Set with selected cymbals.

The following table shows a comparison of the individual kits and their properties:

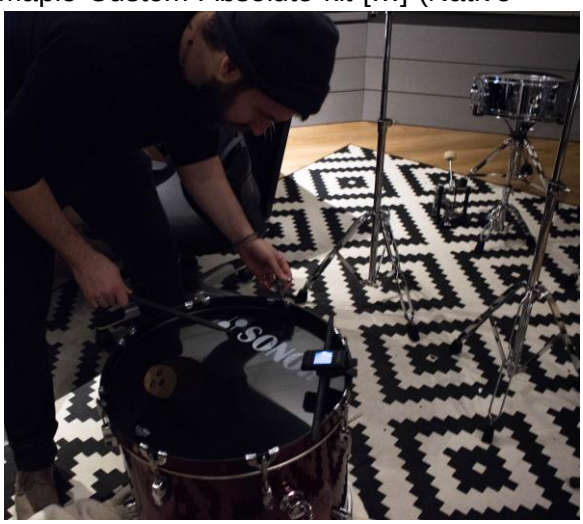

Figure 16: Preparing the hardware (Maislinger,2018)

Part	Yamaha - Kit			Sonor - Kit		
	Modell	Size (inch)		Modell	Size (inch)	
		Circumference	**Depth**		**Circumference**	**Depth**
Kick	Kit Standard	22”	16”	Kit Standard	20”	16”
Snare	Masshoff Drums Avalon Steel Cast	14”	6.5”	Kit Standard	14”	6”
Hang Tom 1	Kit Standard	10”	8”	Kit Standard	10”	7”
Hang Tom 2	Kit Standard	12”	9”	Kit Standard	12”	8”
Floor Tom	Kit Standard	14”	14”	Kit Standard	14”	13”
Hi - Hat	Masterwork Iris	15”	-	Instanbul Melmet Legend	14”	-
Crash	Masterwork Iris	18”	-	Bosphorus Antique Series	20”	-
Ride	Masterwork Custom Pointer	20”	-	Bosphorus Turk Series	21”	-

Table 01: Drum set comparison of the NI Studio Drummer Session Kit and the self-recorded live drum kit, data based on (Native Instruments, 2011, 2019; SONOR, 2019)

5.1.2 Microphones

When choosing and positioning the microphones for the recording of the live drum set, the focus was set on matching the characteristics of the microphones used for the Native Instruments Studio Drummer recording session and, of course, on using the same distances and angles.

Figure 17: Choice of microphones for the live recording session (Maislinger,2018)

The following table shows a comparison of the individual microphones, as well as their positions and properties:

Position	Yamaha - Kit			Sonor - Kit		
	Name	**Polar Pattern**	**Converter Principle**	**Name**	**Polar Pattern**	**Converter Principle**
Kick In	Audio Technica ATM 25	Hyper-Cardioid	Dynamic	Audix D6	Cardioid	Dynamic
Kick Out	Neumann U47 fet	Cardioid	Condenser Large Diaphragm	AKG C214	Cardioid	Condenser Large Diaphragm
Kick Sub	Yamaha SKRM 100	Figure of Eight	Dynamic	Custom	Figure of Eight	Dynamic
Snare Top	Shure SM57	Cardioid	Dynamic	Shure SM57	Cardioid	Dynamic
Snare Bottom	AKG C414	Cardioid	Condenser Large Diaphragm	AKG C414	Cardioid	Condenser Large Diaphragm

Hang Tom 1	Electro – Voice RE 20 + Neumann KM130	Cardioid + Omni diffuse field equalized	Condeser Large Diaphragm+ Condenser Small Diaphragm	AKG C3000	Cardioid	Condenser Large Diaphragm
Hang Tom 2	Sennheiser MD 441 + Neumann KM130	Super Cardioid + Omni diffuse field equalized	CondenserSmall Diaphragm x 2	AKG C3000	Cardioid	Condenser Large Diaphragm
Floor Tom	Sennheiser MD 441 + Neumann KM130	Super Cardioid + Omni diffuse field equalized	CondenserSmall Diaphragm x 2	AKG C3000	Cardioid	Condenser Large Diaphragm
Hi - Hat	Neumann KM140	Cardioid	CondenserSmall Diaphragm	Audio Technica 4051b	Cardioid	Condenser Small Diaphragm
Overheads Stereo	Schoeps MK 4	Cardioid	CondenserSmall Diaphragm	Neumann TLM102	Cardioid	CondenserLarge Diaphragm
Overhead Mono	Coles 4038	Figure of Eight	Ribbon	Audio Technica 4080	Figure of Eight	Ribbon
Room Ambience	Neumann U47	Cardioid	Large Condenser	AKG C214	Cardioid	Condenser Large Diaphragm

Table 02: Microphone comparison of the NI Studio Drummer Session Kit and the self-recorded live drum kit, data based on (AKG, 2019a; Audio Technica, 2019; Audix, 2019; Coles, 2019; Electro Voice, 2019; Native Instruments, 2019; Neumann, 2019; Schoeps, 2019; Sennheiser, 2019; Shure, 2019; SONOR, 2019; Yamaha, 2019)

5.1.3 AD conversion and outboard gear

As for the recording equipment, Native Instruments used the following gear:

Console	=	SSL 9072J
Preamps	=	Millennia HV-308
Compressors/Limiters	=	Fairchild 670, Prism Sound MLA-2

Table 03: AD conversion and outboard gear of the NI Studio Drummer recording, data based on (Native Instruments, 2019)

The recording equipment used for this empirical study consists of the following:

A/D Conversion	=	RME Fireface 802, Behringer Ultragain Pro 8 digital ADA 8000
Preamps	=	RME Fireface 802, Focusrite RED 7, M-Audio Fast Track Ultra 8R
Compressors/Limiters	=	Dbx 160A

Table 04: AD conversion and outboard gear of the live recording (Maislinger, 2018)

5.2 Rooms

The recording of the live drum kit of this bachelor thesis was realized at a recording studio based in Vienna called ‘Soundschmiede’.

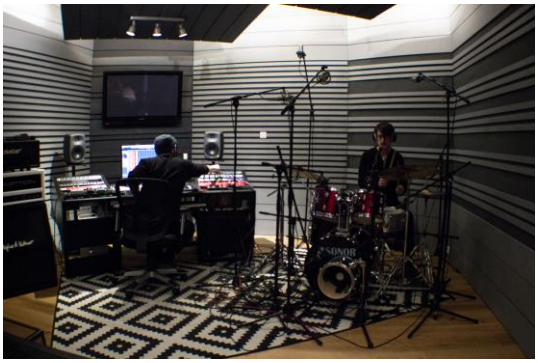

Figure 18: Snapshot Soundschmiede (Maislinger,2018)

The acoustical engineer Thomas Mayer (https://www.raumecho.com/) designed the acoustic circumstances of the recording room together with the studio owner Gerald Hartwagner for a perfect recording environment.

5.2.1 Measurements Soundschmiede

5.2.1.1 Frequency Response

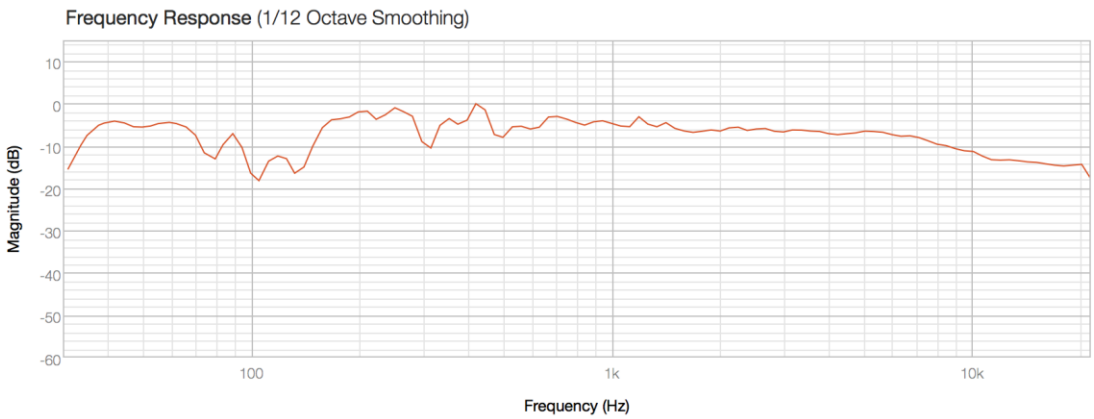

Figure 19: Frequency response of the recording room in the ‘Soundschmiede’ (Mayer, 2018)

5.2.1.2 Reverberation Time

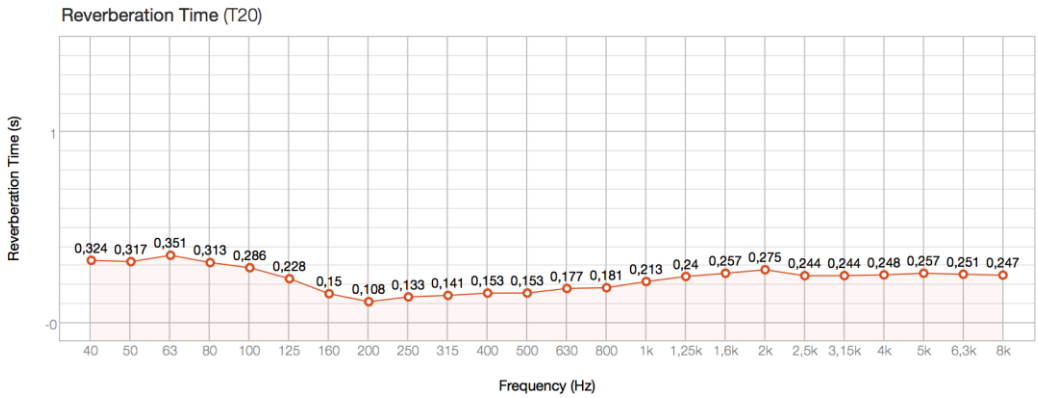

Figure 20: Reverberation time of the recording room in the 'Soundschmiede' (Mayer, 2018)

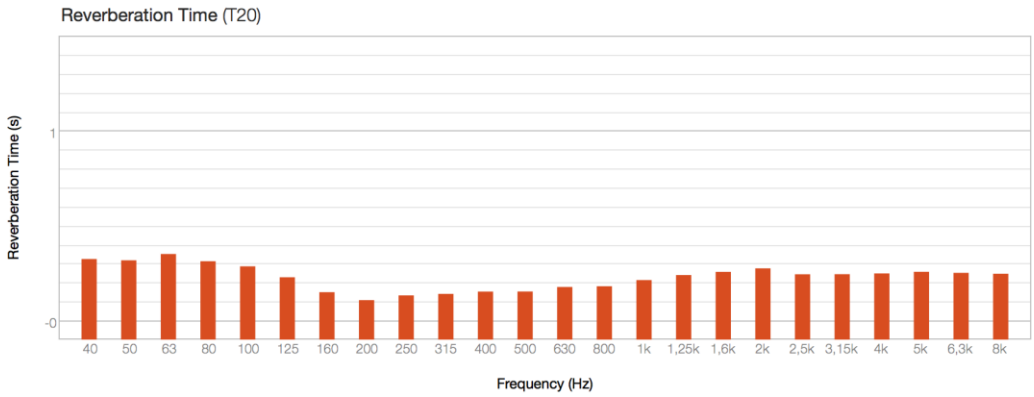

Figure 21: Reverberation time of the recording room in the 'Soundschmiede' (Mayer, 2018)

5.2.1.3 FastForrierTransformation Waterfall Diagram

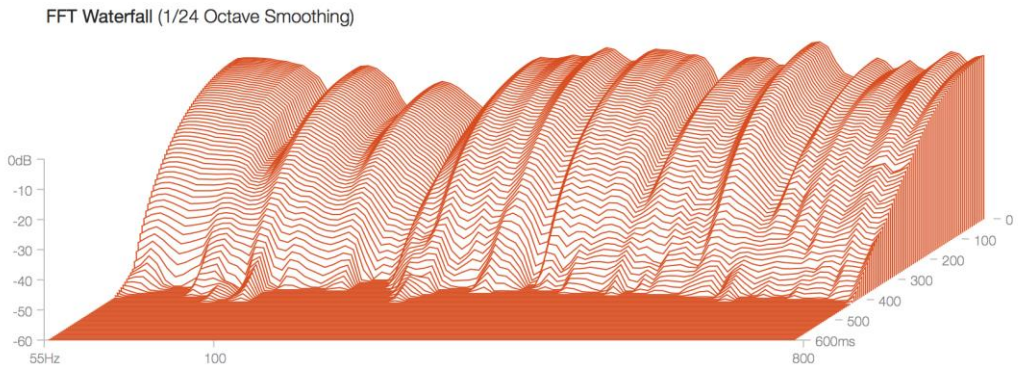

Figure 22: FFT Waterfall of the recording room in the 'Soundschmiede' (Mayer, 2018)

5.2.2 Room – Native Instruments' Studio Drummer

The Native Instruments Studio drummer was recorded in the Teldex Studio Berlin GmbH. This studio has many recording rooms but the one used for the Studio Drummer sample library was their 455m² hall. (Native Instruments, 2011; Teldex Studio, 2019)

Figure 23: 'The Hall' – Recording room at Teldex Studio (Teldex Studio, 2019)

As already mentioned in the description of the virtual instrument above, the Studio Drummer comes with an effect chain included and with that a palette of 30 different convolution reverbs. (Native Instruments, 2019)

The programmed Studio Drummer Session Kit should sound as 'naked' or 'dry' as possible. To achieve that, the whole FX chain, including the convolution reverb, was by-passed.

5.3 Recording

Based on the assumption that Native Instruments has recorded the Studio Drummer plug-in with a rather high bit depth, the recording session for this thesis was preconfigured with a depth of 32 bit and a sample rate of 48 kHz in the DAW Cubase version 9.5

Because of the fact that Native Instruments sell their Studio Drummer plug – in with a bit depth of 24 and a sample rate of 44.1 kHz for the final version, the live recording for this empirical study was rendered down before making further adjustments.

Figure 24 & 25: Snapshots of the recording for this thesis (Maislinger,2018)

5.3.1 Portrait of the drummer

As mentioned earlier in this thesis (see chapter 2.1, p.7), even with gathered room data, selected hard- and software and a perfectly tuned drumkit, the result of a recording session can be a disaster when picking the wrong musician. In the end he or she is the one to get the desired tones out of an instrument. That's why a professional drummer was booked for this empirical study to ensure the best possible outcome.

Lukas Aichinger

Born in Austria in 1992

Studied with Herbert Pirker, Jeff Boudreaux and Christoph Cech at Anton Bruckner University.

Lives and works currently in Vienna as live and studio drummer in different bands and projects.

Figure 26: Portrait of the drummer (Maislinger, 2019)

5.3.2 Grooves

Different rhythms and grooves were recorded on the 5th of December 2018 at the 'Soundschmiede' in Vienna. As the usual bpm (beats per minute) size for virtual instrument groove patterns are between 80 bpm – 150 bpm, two examples with the following velocity values were selected for this thesis: (Winer, 2012)

- 82 bpm
- 122 bpm

List 06: Selected velocities for the drum groove examples (Maislinger, 2019)

5.4 Post production

Before laying hands on the drum replacement, it was important and necessary to clean up the digital recording session. In this context cleaning up means getting rid of silences, mumbling or breathing sounds in between the recordings etc. Those ‘clean’ files where then structured in folders according to the bpm rate of the played groves and imported into the DAW Ableton Live version 10.0.1.

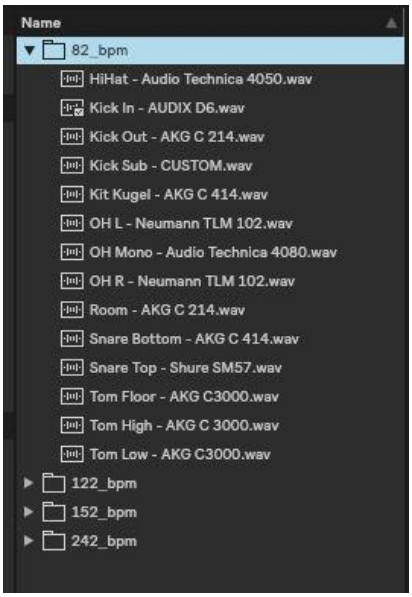

Figure 27: Screenshot of the folder structure of the ‘clean’ files within Ableton Live (Maislinger, 2019)

5.4.1 Converting to MIDI and back to audio

To get precise MIDI data in terms of dynamic and tempo, the audio to MIDI function of the DAW Ableton Live version 10.0.1 has been used. The decision fell on that tool because Ableton Live differs between harmony, melody and drums when converting to MIDI to achieve a more accurate result. When converting the wave files of the self-recorded drum kit into MIDI, it has to be mentioned that not the master bus of the recording was converted into MIDI but rather each part/mic of the kit separately. When a part of the drum set has been microphoned twice or trice as the kick drum for instance, the microphone that

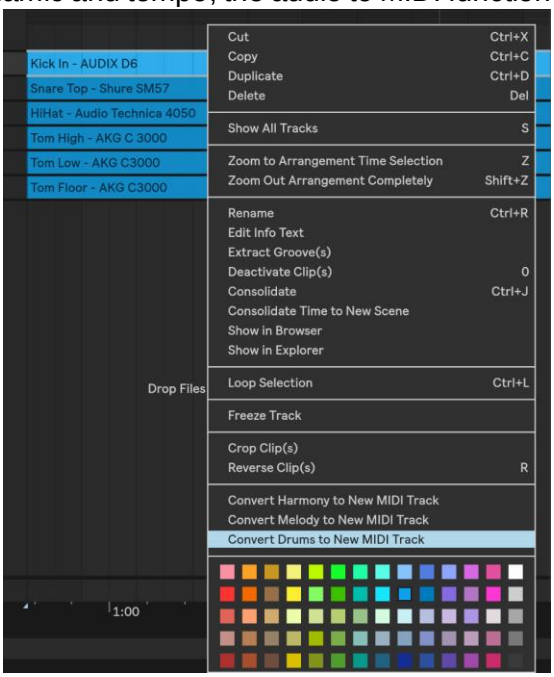

Figure 28: Screenshot of the audio to MIDI function of Ableton Live (Maislinger, 2019)

delivered the most attack has been selected for triggering and conversion purposes. For microphone positions where other parts of the instrument or bleed comes through more easily, the audio files have been gated with the DAW built in gate before, so that only the desired part of the drum kit triggers the MIDI conversion.

Eight MIDI tracks have been created and named after the parts of the kit as followed:

- Kick
- Snare
- Hi-Hat
- Crash
    - OH – R
- Ride
    - OH – L
- Tom High
- Tom Low
- Tom Floor

List 07: Name of the MIDI tracks after the audio to MIDI function within Ableton Live (Maislinger, 2019)

To save processing time, those eight MIDI tracks where rerouted to a new MIDI track and rerecorded, so that the virtual instrument had to be loaded and processed only once and not eight times simultaneously. As an insert on the new MIDI drum track the Kontakt 5 player was loaded along with the Session Kit – Full.nki of the Studio Drummer library by Native Instruments.

Within the Session Kit of the Studio Drummer the correct parts of the instrument (see table 01: drum set comparison, p.28) were selected and the whole effect chain was deactivated. Each fader on Studio Drummer's built-in mixing console was set to 0db, then routed to the Kontakt internal bus system and from there routed to nine separate audio tracks. When playing back the MIDI groove, the signals were then recorded on those new audio tracks to create wave files of the replaced MIDI performance.

The length of this new recorded performance was set accordingly to the one of the live performance and each track was then exported as a 44.1 kHz, 24 bit .wav file.

5.4.2 Mixing

Back into Cubase, the live recording and the replaced tracks were imported, separately grouped and stacked, to have the ability of comparing the kits while listening to them simply via muting one group and the other way around. As for the SONOR live performance version, the amount of bleed has been controlled via the Neutron 2 gate, so it could be adjusted similar to the bleeding tool in the Studio Drummer plug-in. The parameters of the gate were adjusted as followed:

- Kick gate
    - Threshold: -30db
    - Attack: 00,10 milliseconds
    - Release: 70,00 milliseconds
    - Ratio: 30:1

List 08: Parameters of the gate for the kick drum (Maislinger, 2019)

- Snare gate
    - Threshold: -34db
    - Attack: 00.10 milliseconds
    - Release: 70.00 milliseconds
    - Ratio: 30:1

List 09: Parameters of the gate for the snare drum (Maislinger, 2019)

The levels of the faders have been adjusted to accomplish the same output levels from each part of both drumkits to their separate group busses and the master track.

5.4.2.1 Panning

It was decided to pan the drum kits according to the audience's point of view (see chapter 3.1.1, p.18). The panning values in Cubase are visualized from L100 up to R100 (L = left; R = right) and were adjusted as followed for both kits:

- Kick – 0 or C (C = centre)
- Snare – 0 or C
- Hi Hat – R50
- Tom High – R50
- Tom Low – R30
- Tom Floor Tom – L40
- OH L – L100
- OH R – R100
- OH Mono – 0 or C
- Room – 0 or C

List 10: Panning parameters for both drum kits (Maislinger, 2019)

5.4.2.2 Compression

The internal FX chain of the Studio Drummer plug-in was deactivated before recording the files so that in the mixing process the same FXs could be used on both kits. As especially the kick drum and the snare drum nearly never come without compression, compressor pre-sets were configured for both parts that could then be inserted on either of the kits. (Izhaki, 2012; Owsinski, 2014; Savage, 2014; Senior, 2011; Winer, 2012)

The compressor plug-in used was the Fab Filter Pro C2 and the pre-sets were configured as followed:

- **Kick pre-set**
  - Threshold: -4.44db
  - Attack: 0.17 milliseconds
  - Release: 87.40 milliseconds
  - Ratio: 6.24:1
  - Wet Gain: +5.09db
  - Dry Gain: -INFdb
  - Input Level: +8.47db
  - Output Level: 0db

List 11 Configured parameters for the kick drum compressor pre-set (Maislinger, 2019)

- **Snare pre-set**
  - Threshold: -16.64db
  - Attack: 0.10 milliseconds
  - Release: Auto Release 9.3%
  - Ratio: 4:1
  - Wet Gain: +2.13db
  - Dry Gain: -12db
  - Input Level: +1.85db
  - Output Level: 0db

List 12: Configured parameters for the snare drum compressor pre-set (Maislinger, 2019)

5.4.2.3 Equalization

In order to have the same modification when it comes to the frequency spectrum of both drum kits, a group equalization pre-set was configured for the group drum busses using the Fab Filter Pro Q3 plug-in. The parameters of the different bands were configured as followed:

- Low Cut
  - 20 Hz
  - 24db/octave
  - Q: 0.3
- Low Shelf
  - 50 Hz
  - -1db
  - Q: 1.0
- 1. Bell
  - 100 Hz
  - +2db
  - Q: 1.0
- 2. Bell
  - 5000 Hz
  - +2db
  - Q: 1.0
- High Shelf
  - 10000 Hz
  - +1db
  - Q: 1.0
- High Cut
  - 30000 Hz
  - 24db/octave
  - Q: 1.0

List 13 Configured parameters for the Fab Filter Q3 equalizer (Maislinger, 2019)

5.4.2.4 Reverberation

As for the room, the thing that had to be kept in mind was that the Studio Drummer was recorded in a big hall and the live kit was not. That's why the track of the room mic of the Studio Drummer was sparely used and all convolution reverb effects were muted to get the 'driest' version possible and to match the room conditions of the live performance (see figure 21, p.33).

Both of those room matched drum kits were then sent to an artificial reverb to simulate a digital room that has the same conditions for both kits.

The reverb used was the RC 48 from Native Instruments with the following parameters:

- Pre-Delay: 24.0 milliseconds
- Shape: 126
- Size: 25 meters
- Bass: 1.12
- Mid: 1.75
- High Cut: 4.38 kHz
- Diffusion: 99

- Spread: 162
- Crossover: 764kHz
- RevDamp: 3.99kHz
- Wet/~~Dry~~
- Reverb/~~Effect~~

List 14: Configured parameters for the RC 48 Reverb (Maislinger, 2019)

The send fader to the reverb bus was set on -20db for both drum kit groups while the bus of the reverb remained at 0 db.

5.4.2.5 Music

Because of the assumption, that apart from drummers and drum specialists, the general public listens to drums mostly in combination with other instruments, a piece of music was composed for three more instruments per groove. The music was recorded via MIDI using the drum grooves as playback.

The instruments used for the 82bpm groove as well as for the 122bpm groove were:

- Alto Sax – Native Instruments Kontakt Factory Library
    - Standard configuration
- Mark II Classic – Native Instruments Kontakt Factory Library
    - Standard configuration
- Scarbee Jay- Bass Slap Neck – Native Instruments
    - Standard configuration

List 15: Virtual instruments used for the composed music (Maislinger, 2019)

After the music was performed and recorded, it was sent to the same reverb bus as the one of the drum kits. This step was decided, because everything should fit together and to simulate one recording room for all instruments. (Izhaki, 2012; Owsinski, 2014; Savage, 2014; Senior, 2011; Winer, 2012)

5.4.2.6 Mixdown

According to the resolution of the Studio Drummer samples, both grooves with both drumkits were exported with 44.1 kHz and a bit depth of 24 bit. From each groove and each kit, two versions were exported. One with music and one without.

Resulting in four files in total. The length of the 82bpm grooves is 00:32 min and the length of the 122bpm grooves is 00:39 min.

The files were named as followed:

- A_STUDIODRUMMER_82_BPM_MUSIC.wav
- A_STUDIODRUMMER_82BPM.wav
- B_SONOR_82_BPM_MUSIC.wav
- B_SONOR_82_BPM.wav
- A_SONOR_122_BPM_MUSIC.wav
- A_SONOR_122_BPM.wav
- B_STUDIODRUMMER_122_BPM_MUSIC.wav
- B_STUDIODRUMMER_122_BPM.wav

List 16: Naming of the example files (Maislinger, 2019)

The letters A and B stand for the multiple-choice letters and therefore the correct solutions in the questionnaire created for this thesis.

5.5 Survey

"**Survey research** a research method involving the use of standardized questionnaires or interviews to collect data about people and their preferences, thoughts, and behaviours in a systematic manner." (Bhattacherjee, 2012, p.73)

Based on the data gathering and survey literature of Bhattacherjee, 2012 as well as Gerring & Christenson, 2017 and the collected information and references of A/B testing of Ron Kohavi along with Roger Longbotham, 2015, a specific survey has been developed for this thesis.(Bhattacherjee, 2012; Gerring & Christenson, 2017; Longbotham & Kohavi, 2015)

Bhattacherjee divides survey research into two broad categories: (Bhattacherjee, 2012)

- Questionnaire Surveys
- Interview Surveys

(Bhattacherjee, 2012)

While interview surveys mostly are completed personally, and a questionnaire can be realized online, for this thesis it was necessary to create a hybrid version of those two categories to achieve scientific accuracy in terms of providing the right acoustic environment.

5.5.1 Target Group

The target group or as Gerring, J. and Christenson D. are calling it in their book ‘Data Gathering’ from 2017 “focus group” (Gerring & Christenson, 2017, p.212) of this thesis consists of individuals of any gender from the age of 15 to 60. These individuals should be categorized as laywomen and laymen in the audio sector. The target group should not be represented by specialists. Specialist in the audio sector is hereby defined as an individual whose major income is based on an audio-related profession.

5.5.2 Listening conditions

As the target group consists of laywomen and laymen in the audio industry and based on the statistics of the devices used for music listening, it would be sufficient to playback the audio files of the questionnaire on a smartphone. From an acoustic precision aspect though, the listening phase of the questionnaire would have to be in a studio with an adequate linear studio speaker system or even in the studio were the mixdown was created. (Izhaki, 2012; Olive, Welti, & Mcmullin, 2013; Owsinski, 2014; Prodi, Visentin, & Bellettini, 2012; Savage, 2014; Statista, 2019a; Winer, 2012)

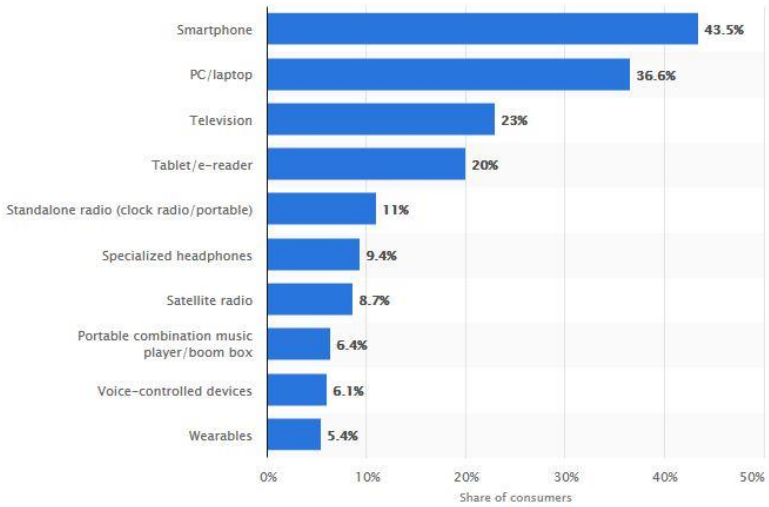

Figure 29: “The graph shows devices used by Americans for listening to music in the United States as of 2017.” (Statista, 2019)

Considering acoustic accuracy, consumer habits and the mobility aspect of testing locations in order to increase the quantity of participants, the decision for the sound source of the testing fell on the **AKG - K712 PRO** headphones. Those are open and linear studio headphones with a rated impedance of 62 Ohms and an audio frequency bandwidth of 10 – 39800 Hz. (AKG, 2019)

Figure 30: AKG – K712 PRO (AKG, 2019)

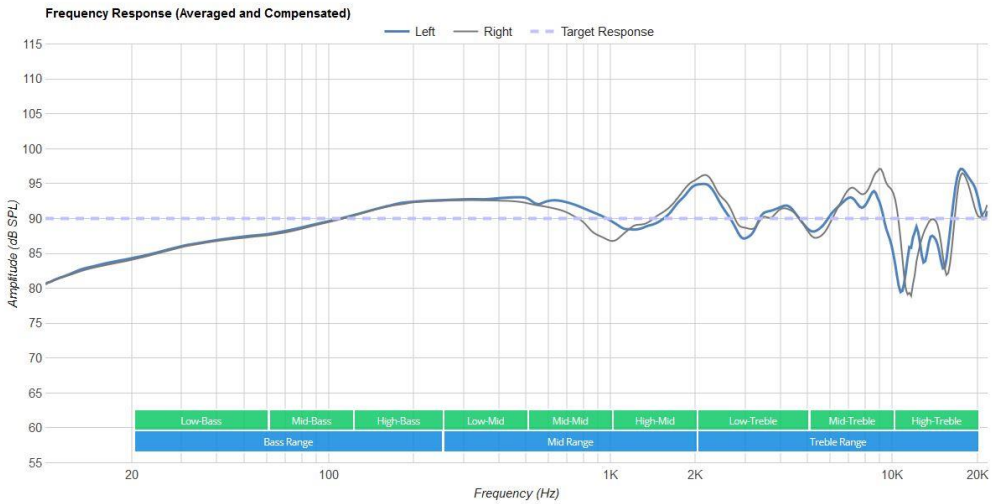

Figure 31: Frequency response of the AKG – K712 PRO headphones (Vafaei, Henney, & Lamontagne, 2016)

5.5.3 Questionnaire

"Invented by Sir Francis Galton, a questionnaire is a research instrument consisting of a set of questions (items) intended to capture responses from respondents in a standardized manner." (Bhattacherjee, 2012, p.74)

Because of the quality and simplicity of visualizing the results of the gathered data of this questionnaire, it was decided to design it structured, meaning that a static set of answers already exists, and the respondent only has to choose among them instead of responding in their own words like it would be in an unstructured questionnaire. (Bhattacherjee, 2012)

When it comes to creating the questions and answers, the focus was also set on a clear and specific result. Therefore they were designed in a way that the responded only has the choice of how Bhattacherjee titles it 'dichotomous' (=only two possible answers, for example yes/no) and 'nominal' (= "[…]more than two unordered options" (Bhattacherjee, 2012, p.75)) responses.(Bhattacherjee, 2012)

Considering the collected information of data gathering literature, the questionnaire begins with an agreement between the respondent and the interviewer that the participation in this survey is voluntarily. The questions have a specific order. Beginning with basic questions about the respondent's background information should confer them and avoid a stressful testing situation. They are designed to avoid wording in negative manner and continuously stay clear and understandable, meaning the questions are not too detailed or too general. Presumptuous questions have been avoided and respondents do not need background information about the subject. (Bhattacherjee, 2012; Gerring & Christenson, 2017; Longbotham & Kohavi, 2015)

5.5.3.1 Questions and choice of responses

The following text represents the explanations, questions and answers used in the questionnaire for this thesis:

5.5.3.1.1 Page 1 - Explanation

Because recording acoustic drums is, in a lot of cases, the most time-consuming part of a music production for recording engineers, the goal of this thesis and survey is to find out if the difference between live drum recording and replacing a drummer's performance with samples (pre-recorded drum sounds) is still audible to the laywomen and laymen.

5.5.3.1.2 Page 2 - Preparation

I agree that I take part of this questionnaire voluntarily and that I have been provided with the **AKG - K712 PRO** linear headphones. (Answer required)

- ☐ I agree

Figure 32: AKG – K712 PRO (AKG, 2019)

5.5.3.1.3 Page 3 – Basic Information

```
Question 1
```

Which gender do you have? (Answer required)

- ☐ Male
- ☐ Female
- ☐ Other

Question 2

How old are you? (Answer required)

- 15 – 19
- 20 – 30
- 30 – 40
- 40 – 60

Question 3

Do you play an instrument? (Answer required)

- Yes
- No

Question 4

If so, is it a hobby or your profession? (No answer required)

- Hobby
- Profession

Question 5

Has your current profession anything to do with sound?

- Yes
- No

Question 6

How many hours do you actively listen to music per week? (By active is meant that you focus only on the music you are listening to and nothing else) (Answer required)

- 0
- 1 – 3
- 3 – 5
- 5 +

5.5.3.1.4 Page 4 – First example groove

You are going to be played two versions of the same piece of music, one with the live recorded drum set and another with the sample-based replacement. Afterwards you are going to be asked a few questions about your opinion of the two versions.

Samples

The link below will open example – A

https://drive.google.com/open?id=1rKW-KlqnTeOrcDawvzl50B6OJsRqGD4v

The link below will open example – B

https://drive.google.com/open?id=1LpQrg2uOpxUHvhisxTvLNO8rEJrpW3AL

Question 1

Which one of the examples, in your opinion, was the live recording? (Answer required)

- A
- B

Now you are going to be played the same pieces of music but without the rest of the instruments, meaning the drums will be played solo.

Samples

The link below will open example – A drums solo

https://drive.google.com/open?id=1PDUm2gEN43NtJZP-LzOKqsZRcZT-2b7V

The link below will open example – B drums solo

https://drive.google.com/open?id=14JLvmrgdf5OBVL6ZVAhf-9MsxAgwM49w

Question 2

Which one of the examples, in your opinion, was the live recording? (Answer required)

- A
- B

5.5.3.1.5 Page 5 – Second example groove

Again, you are going to be played two versions of the same piece of music, one with the live recorded drum set and another with the sample-based replacement. This time the tempo of the music has been changed. Like before, you are going to be asked a few questions about your opinion of the two versions afterwards.

Samples

The link below will open example – A

https://drive.google.com/open?id=1LFlwLmxa3X82m8SKQYkV0JgMDGV5ofjW

The link below will open example – B

https://drive.google.com/open?id=1Hz8JPgeV6GZMBwd3ov9TrjI3kfe5cd94

```
Question 1
```

Which one of the examples, in your opinion, was the live recording? (Answer required)

- A
- B

As before you are going to be played the same pieces of music but without the rest of the instruments, meaning the drums will be played solo.

```
Samples
```

The link below will open example – A drums solo

https://drive.google.com/open?id=1agkGAwpDYrfS2RN4yi8hUbUJwtVJFWDS

The link below will open example – B drums solo

https://drive.google.com/open?id=11XXp4VgTfHLp7FgeCwLeOe8cbHX2sLR-

```
Question 2
```

Which one of the examples, in your opinion, was the live recording? (Answer required)

- A
- B

5.5.3.1.6 Page 6 – Final question

Before listening to all the files, which one of the drum kits did you expect to sound better? (Answer required)

- The real one
- The replaced one

5.5.3.1.7 Page 7 – Gratitude

Thank you for your time and being part of this questionnaire. If you are interested in the result, please fill in your email address below and as soon as it is finished it will be sent to you.

eMail address:

respondentmail@example.com

5.6 Testing phase

The testing was held in Austria from June 1st to June 23rd in 2019. To take advantage of the mobility aspect of using the AKG K712 Pro studio headphones as the listening reference, a mobile version for the testing has been prepared.

As the questionnaire was created in **Google Forms** it could easily be loaded on a tablet (in this case an iPad Air 2) which was then connected to the AKG K712 Pro studio headphones. The only remaining factor of dependency was an internet connection and a quiet surrounding. Both of those aspects have been taken into account during the testing phase.

5.6.1 Participants

In total 45 individuals participated in the questionnaire of the survey for this bachelor thesis.

Considering bias factors and different mood states of the participants in relation to the time of day, the attendees were interviewed accordingly. That is also why the decision did not fell on a group testing but rather on individual testing phases so that this aspect could be controlled and selected by the interviewer. (Bhattacherjee, 2012; Gerring & Christenson, 2017)

5.7 Evaluation

The evaluation data is based on the results of the questionnaire of this bachelor thesis ‘Live drums vs. MIDI based drum replacement’ created in Google Forms. The tools used for the following stats and charts are all based on Google Docs applications.

5.7.1 Summary

The following tables and charts represent the answers of all individuals that participated in this questionnaire:

Points	0	1	2	3	4
# of respondents	6	7	18	7	7

Table 05: Table about how many people scored how many points (Maislinger, 2019)

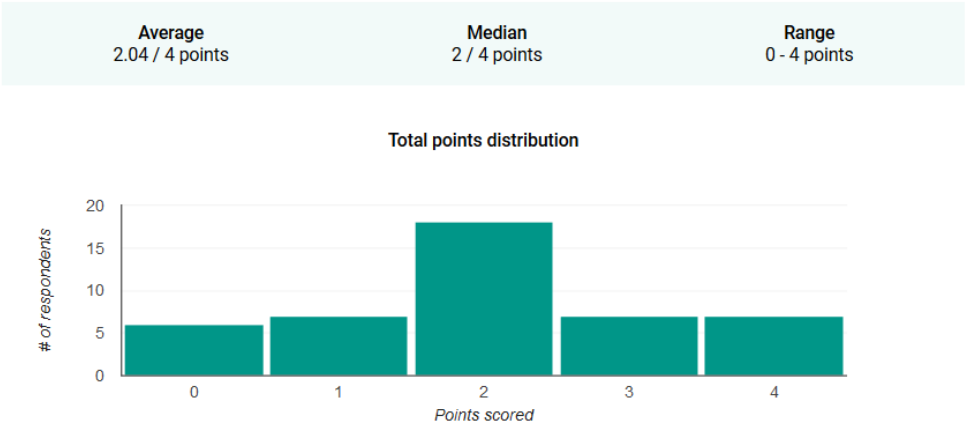

Figure 33: Chart about the points achieved by the participants (Maislinger, 2019)

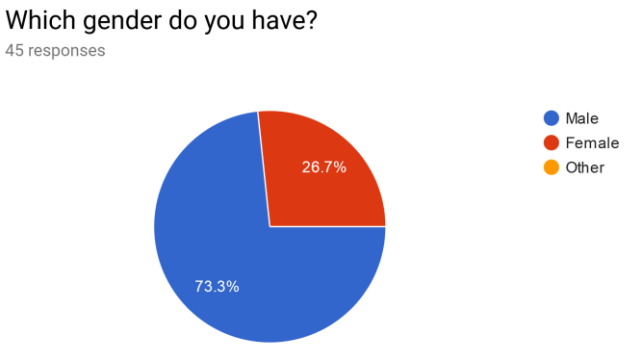

Figure 34: Chart about the ratio of the gender of the participants (Maislinger, 2019)

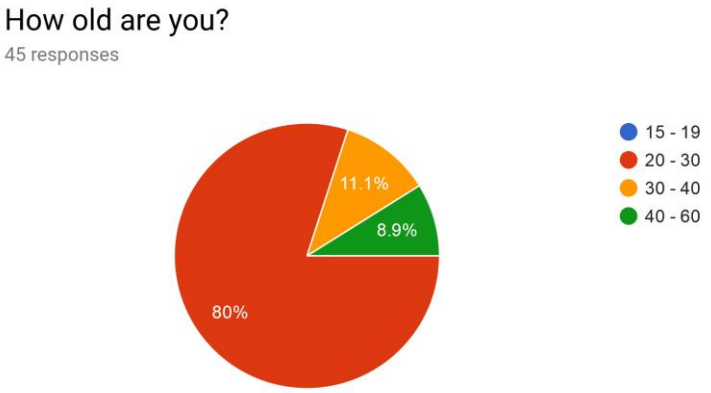

Figure 35: Chart about the ratio of the age of the participants (Maislinger, 2019)

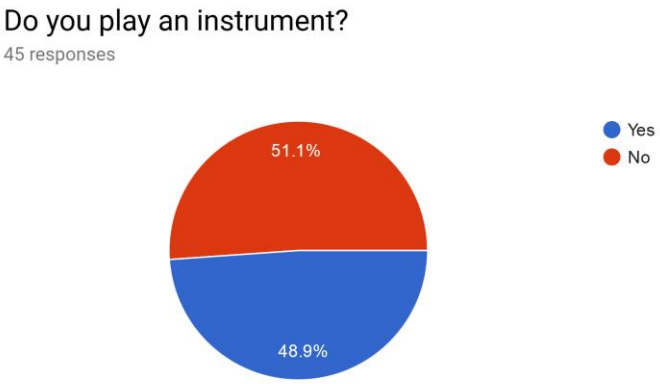

Figure 36: Chart about the ratio of instrumentalists to non-instrumentalists of the participants (Maislinger, 2019)

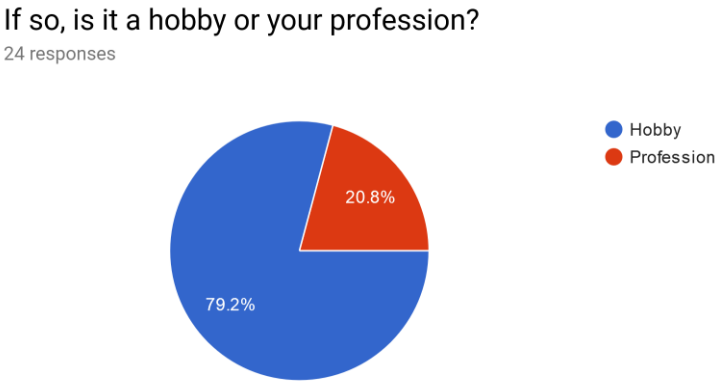

Figure 37: Chart about the ratio of professional to hobby instrumentalists of the participants (Maislinger, 2019)

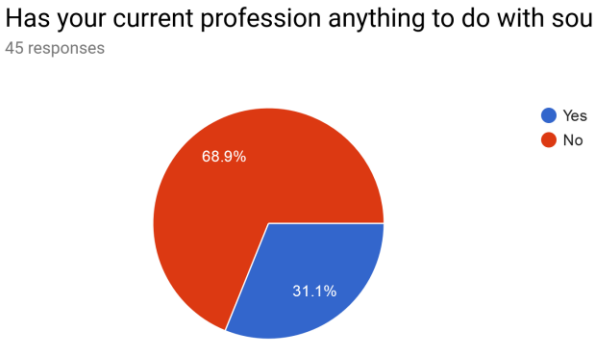

Figure 38: Chart about the ratio of laywomen and men to audio specialists of the participants (Maislinger, 2019)

Figure 39: Chart about the active music listening hours of the participants (Maislinger, 2019)

Answers to the first example group – drums with other instruments:

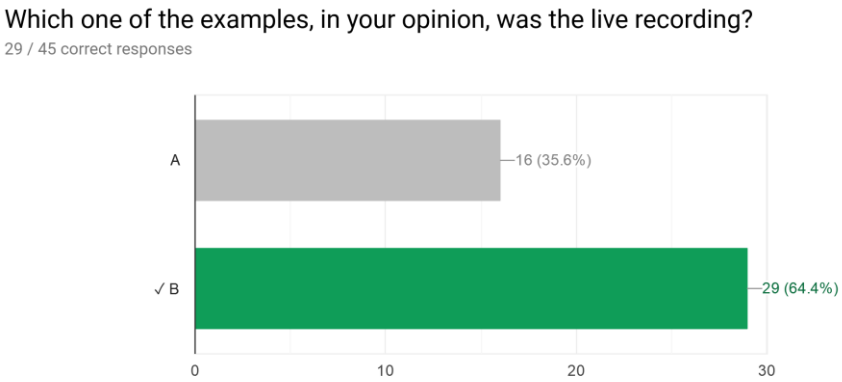

Figure 40: Chart about the correctness of the answers of the first AB question (Maislinger, 2019)

Answers to the first example group - drums solo:

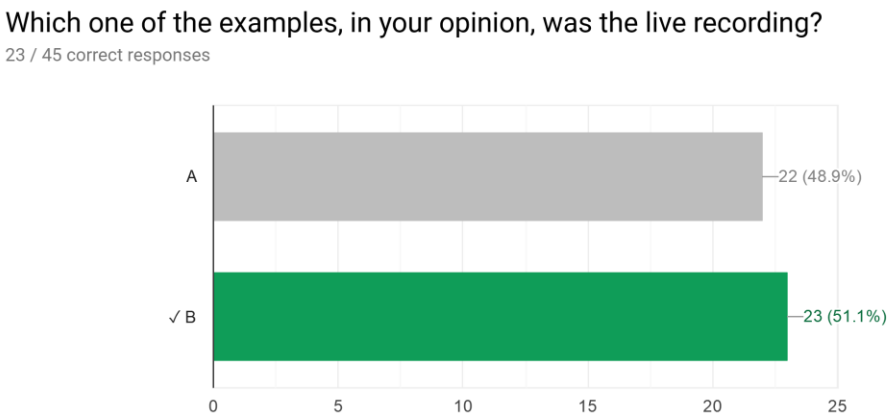

Figure 41: Chart about the correctness of the answers of the second AB question (Maislinger, 2019)

Answers to the second example group – drums with other instruments:

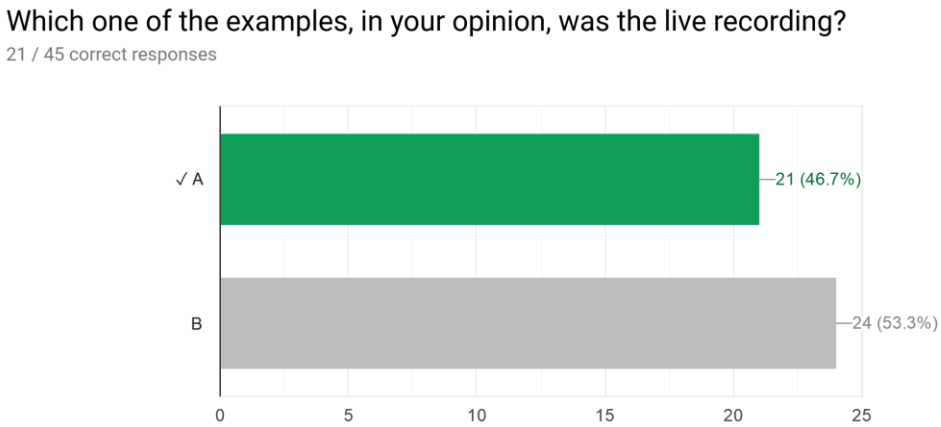

Figure 42: Chart about the correctness of the answers of the third AB question (Maislinger, 2019)

Answers to the first example group - drums solo:

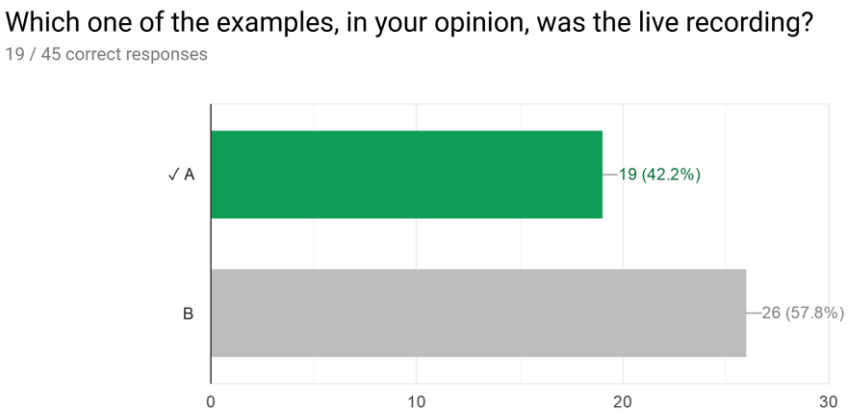

Figure 43: Chart about the correctness of the answers of the fourth AB question (Maislinger, 2019)

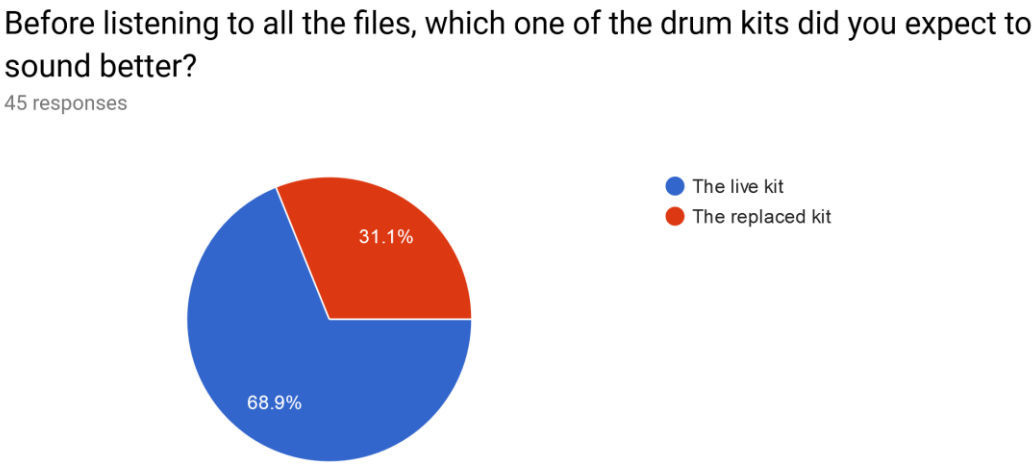

Figure 44: Chart about the ratio of the opinion based on the sound of live vs. replaced drumkits of the participants (Maislinger, 2019)

5.7.2 Individual Evaluation

By analysing the gathered data of the questionnaire, the individual statistics resulted as followed:

5.7.2.1 Age

The following chart shows the average score reached for each age category. It clearly shows that the category 40-60 has reached nearly a perfect score while in the other two categories only approximately every second answer seemed to be correct. Although a quite important factor that has to be kept in mind is the number of participants for each age group (see figure 35, p.53). What is interesting though, is the fact that three out of the four participants in the age of 40-60 are playing an instrument, so that could be a factor that influenced the good result for that age category.

Age of participants	Average score
20 – 30	47.92%
30 – 40	49.58%
40 – 60	93.75%

Table 06: Table about the average score of each age group of the participants (Maislinger, 2019)

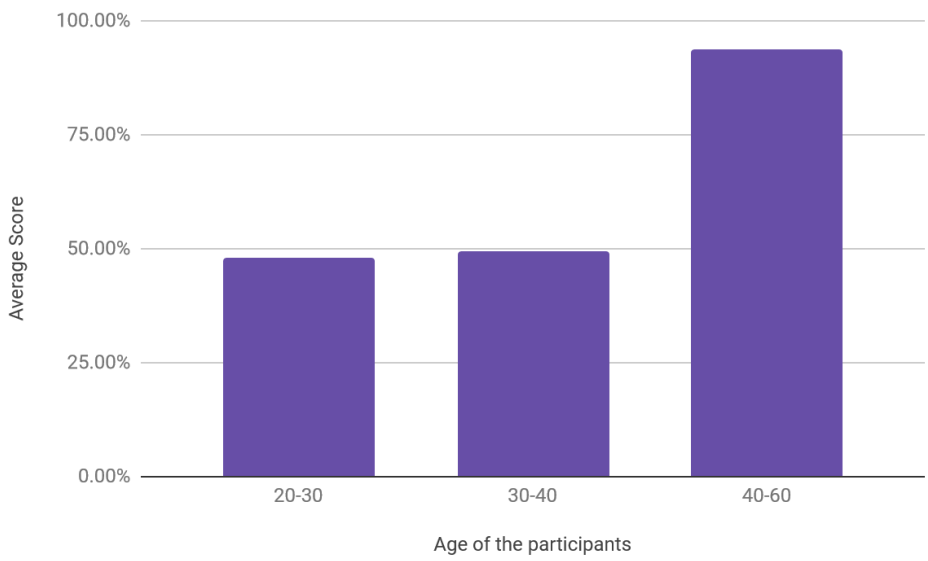

Figure 45: Chart about the average score of each age group of the participants (Maislinger, 2019)

5.7.2.2 Instrumentalists

The following results are determining the assumption made in chapter 5.7.2.1 on page 57, that the elder generation has reached such a good result only because 75% of them played an instrument, because although as the following graphics show, the average score of the individuals who are playing an instrument is slightly better, the contrast is not significant enough to make that kind of an assumption.

Instrumentalists	Average score
Yes	52.18%
No	48.12%

Table 07: Table about the average score of instrumentalists and non-instrumentalists (Maislinger, 2019)

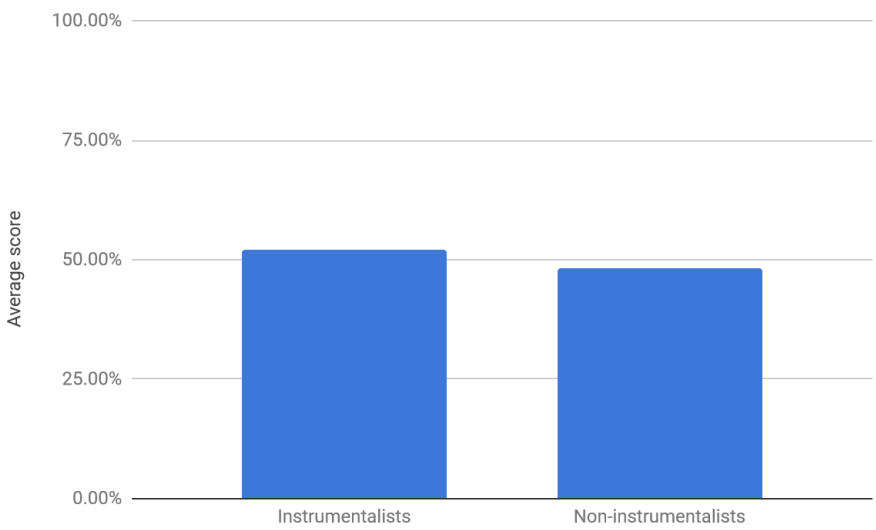

Figure 46: Chart about the average score of instrumentalists and non-instrumentalists (Maislinger, 2019)

Instrumentalists	Average score
Hobby instrumentalists	51.09%
Non-instrumentalists	48.12%

Table 08: Table about the average score of hobby instrumentalists and non-instrumentalists (Maislinger, 2019)

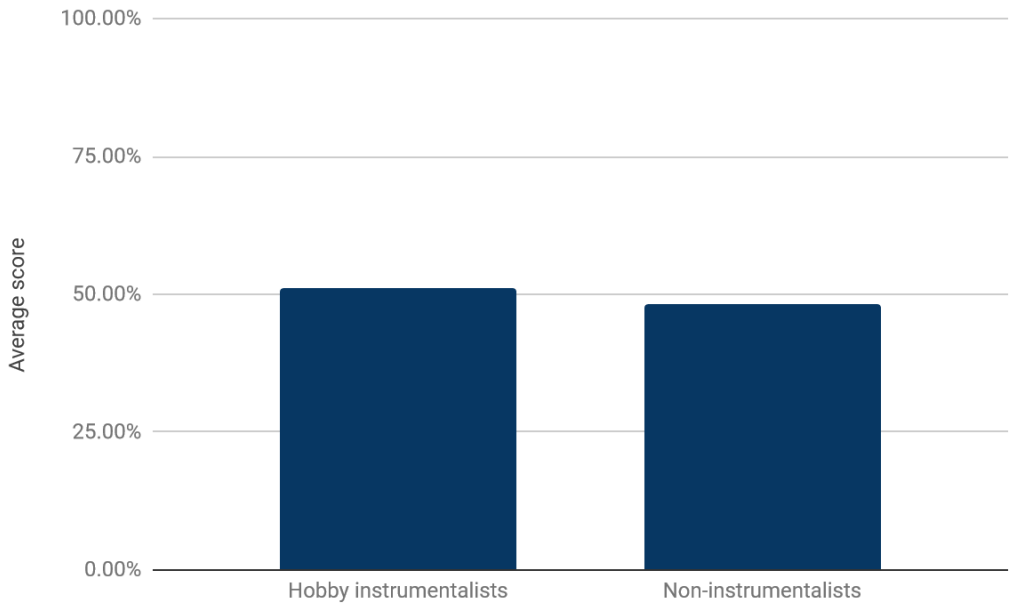

Figure 47: Chart about the average score of hobby instrumentalists and non-instrumentalists (Maislinger, 2019)

What is quite surprising though, is the fact that the average score of the professional instrumentalists do not differ a lot from the hobby instrumentalists based on the answers of the participants of this questionnaire.

Instrumentalists	Average score
Hobby instrumentalists	51.09%
Professional-instrumentalists	52.80%

Table 09: Table about the average score of hobby instrumentalists and professional-instrumentalists (Maislinger, 2019)

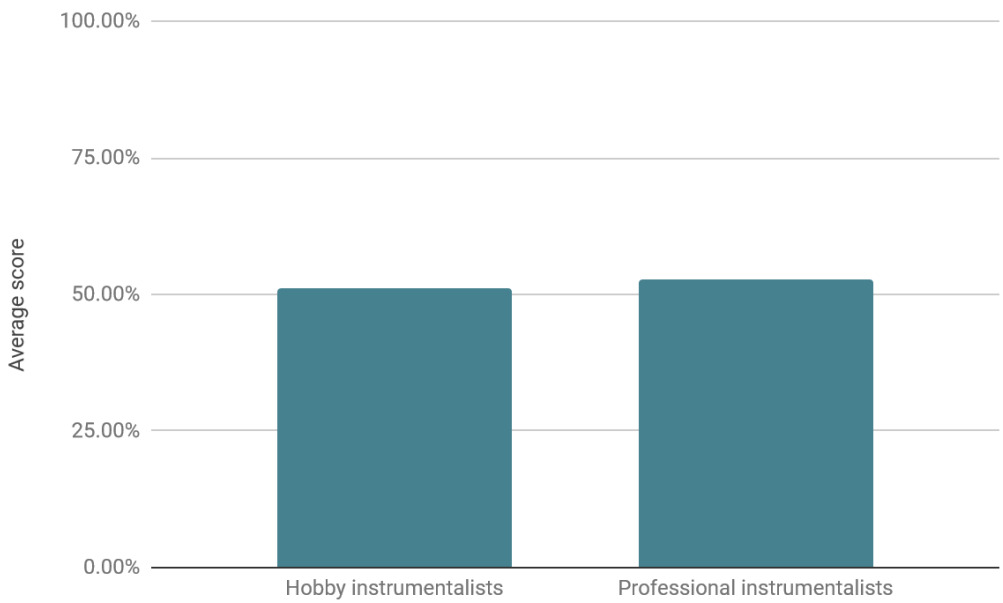

Figure 48: Chart about the average score of hobby instrumentalists and professional-instrumentalists (Maislinger, 2019)

5.7.2.3 Audio related profession

The following statistic is probably the most surprising one. Normally one might expect that people who are working in the audio industry would reach a far better score than laywomen and laymen. But as the results show they are worse, even if it is just for a few per cent. Based on that statistic one could assume that because modern productions are so much used to a replaced drum kit sound, even for a trained ear it is hard to tell the difference. But in order to proof that assumption, more questionnaires and tests would have to be created with professionals of the audio industry as a target group and a way bigger quantity of participants.

Audio specialist	Average score
Yes	49.95%
No	51.09%

Table 10: Table about the average score of laywomen and laymen and specialists in the audio sector (Maislinger, 2019)

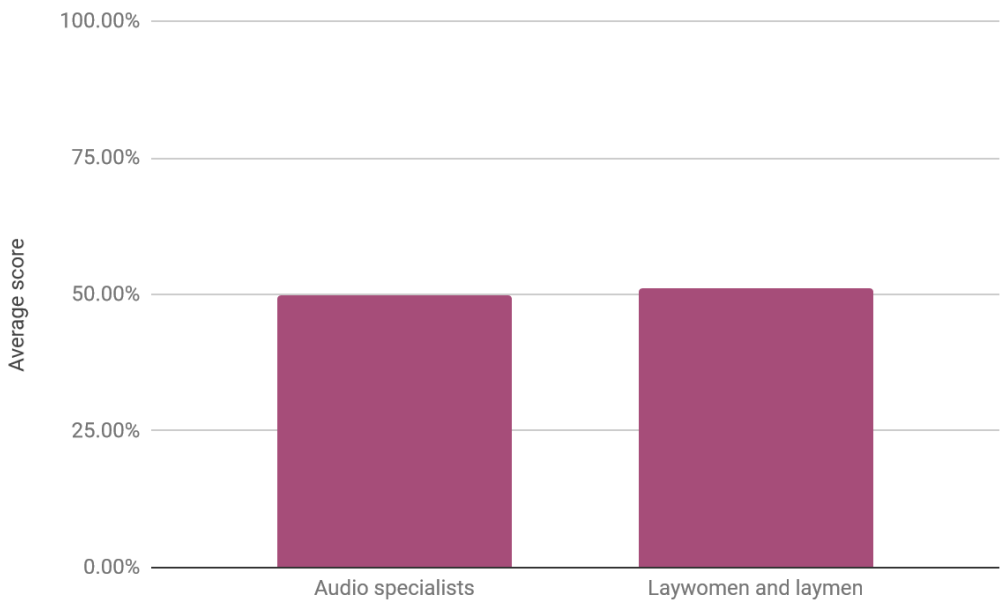

Figure 49: Chart about the average score of laywomen and laymen and specialists in the audio sector (Maislinger, 2019)

5.7.2.4 Active music listening hours

Apart from the average score of the only 2 out of 45 participants who answered that they are listening actively to music for not even an hour per week (see figure 39, p.54), one could make the assumption that the more people are listening to music actively, the better they can tell the difference of a live and a replaced drumkit. Again, to proof this assumption more tests specifically focusing on that subject would have to be created and analysed.

Active music listening hours	Average score
0	49.70%
0 – 3	46.47%
3 – 5	51.09%
5+	51.11%

Table 11: Table about the average score of the groups of the participant's active music listening hours (Maislinger, 2019)

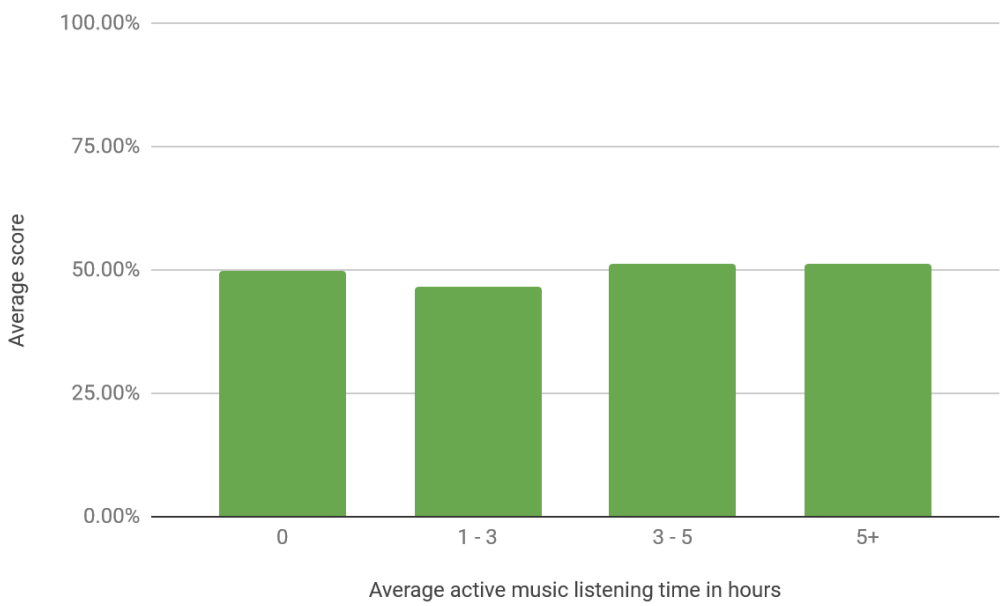

Figure 50: Chart about the average score of the groups of the participant's active music listening hours (Maislinger, 2019)

6 Conclusion

The goal of this bachelor thesis was to find a possible answer to the question if there still exists an audible difference between live drums and MIDI based drum replacement. Considering the results of the survey, being an average score of two out of four correct answers, it can be assumed that yes, there still is an audible difference.

A difference yes, but the awareness of whether listening to a live kit or a drum replacement maybe not. About one third (see figure 44, p.56) of the participants expected the replaced drum kit to sound better anyway and only 7 people, meaning 15.56% of all individuals who participated in this questionnaire, knew at all times which of the example files that they were listening to was the live drum kit and which was not (see table 05, p.52). So, one could assume that if the budget of a production allows it, hiring a professional drum recording engineer is a nice thing to have, but according to the consumer probably not a must if the difference is only heard about 50% at a time according to the results of this survey. Of course, it is important to mention that this is only an assumption. Proofing this assumption would require a higher quantity of participants and probably more example files. Especially from a technical aspect it is still difficult to replace faster and more complex drum grooves. (During the audio to MIDI transformation of this thesis, misplaced ghost notes of the snare drum occurred quite often when the bpm size of the recording was above 180 bpm.)

Technical improvements are evolving on a continuous and rapid rate and maybe some day all the music will be produced only on MIDI base and no real instruments are no longer needed anymore. Only time can tell.

Summarizing, one can assume that as long as the grooves stay simple and their velocity is beyond a bpm size that drum replacement tools can measure without further difficulties, drum replacement is a great and powerful tool for each low budget music production, that should be considered at all times.

References

AKG. (2019a). AKG shop - Official AKG Store - Headphone with quality sound! Retrieved May 23, 2019, from https://uk.akg.com/

AKG. (2019b). K712 PRO | Reference studio headphones. Retrieved June 15, 2019, from https://www.akg.com/Headphones/Professional%20Headphones/K712PRO.html?

Audio, H. (2018, May 2). How to Pick A Microphone For a Podcast. Retrieved March 14, 2019, from How to Pick A Microphone For a Podcast website: https://hookeaudio.com/blog/podcasting/how-to-pick-a-microphone-for-a-podcast/

Audio Technica. (2019). Audio-Technica - Headphones, Microphones, Wireless Systems & More. Retrieved May 23, 2019, from https://eu.audio-technica.com/

Audix. (2019). Drum Microphones, Instrument Microphones, Choir Microphones, Dynamic Microphones, Condenser Microphones and Vocal Microphones from Audix. Retrieved May 23, 2019, from https://audixusa.com/

Bhattacherjee, A. (2012). *Social science research: Principles, methods, and practices*.

Coles. (2019). Coles Electro Acustics. Retrieved May 23, 2019, from http://www.coleselectroacoustics.com/

Electro Voice. (2019). Pro Audio Speakers, Microphones, Amps & DSP by Electro-Voice. Retrieved May 23, 2019, from Pro Audio Speakers, Microphones, Amps & DSP by Electro-Voice website: http://www.electrovoice.com/index.php?

Garfield, R. (2016). *What Do You Do*. Retrieved from https://www.youtube.com/watch?v=QBAM8EefNsY

Gerring, J., & Christenson, D. (2017). *Applied Social Science Methodology: An Introductory Guide*. Cambridge, United Kingdom ; New York: Cambridge University Press.

Görne, T. (2014). *Tontechnik: Hören, Schallwandler, Impulsantwort und Faltung, digitale Signale, Mehrkanaltechnik, tontechnische Praxis* (4., aktualisierte). München: Carl Hanser Verlag GmbH & Co. KG.

Izhaki, R. (2012). *Mixing audio: Concepts, practices and tools* (2nd ed). Amsterdam ; Boston: Focal Press.

Longbotham, R., & Kohavi, R. (2015). *Online Controlled Experiments and A/B Tests*. 11.

Mayer, T. (2018). raumecho - Gebäude Akustik optimieren, Guntramsdorf, Niederösterreich. Retrieved May 24, 2019, from Raumakustik verbessern - Wien / Niederösterreich - raumecho website: https://www.raumecho.com/kontakt

Mistele, A. (2012). *Getting Pro: Methoden, Tricks und Hintergründe für professionelle Audioproduktionen* (3rd ed.). Berlin: epubli.

Native Instruments. (2011). *The making of STUDIO DRUMMER | Native Instruments*. Retrieved from https://www.youtube.com/watch?v=Wqv5ObFOUAo

Native Instruments. (2019). STUDIO DRUMMER. Retrieved May 13, 2019, from https://www.native-instruments.com/products/komplete/drums/studio-drummer/

Neumann. (2019). Microphones Neumann. Retrieved May 23, 2019, from https://en-de.neumann.com/microphones#

Olive, S. E., Welti, T., & Mcmullin, E. (2013). *A VIRTUAL HEADPHONE LISTENING TEST METHODOLOGY*. 10.

Owsinski, B. (2009). *The recording engineer's handbook* (2nd ed). Boston, MA: Course Technology Cengage Learning.

Owsinski, B. (2014). *The Mixing Engineer's handbook* (Third edition). Australia: Course Technology, Cengage Learning.

Prodi, N., Visentin, C., & Bellettini, C. (2012). *Listening Efficiency Testing*. 6.

Savage, S. (2014). *Mixing and mastering in the box: The guide to making great mixes and final masters on your computer*. Oxford: Oxford University Press.

Schoeps. (2019). Home | SCHOEPS Mikrofone. Retrieved May 23, 2019, from https://schoeps.de/en.html

Senior, M. (2011). *Mixing Secrets in the small studio*. Burlington, MA: Taylor & Francis Ltd.

Sennheiser. (2019). Sennheiser - Headphones & Headsets - Microphones - Business Communications. Retrieved May 23, 2019, from https://en-us.sennheiser.com/

Sheps, A. (2018). *Andrew Scheps at the University of Oxford - "What Comes Out Of The Speakers". - YouTube*. Retrieved from https://www.youtube.com/watch?v=HVCdrYbUVW8

Shier, J., McNally, K., & Tzanetakis, G. (2017). Analysis of Drum Machine Kick and Snare Sounds. *New York*, 6.

Shure. (2019). Shure: Microphones, Wireless microphones, in-ear monitoring, earphones, headphones. Retrieved May 23, 2019, from https://www.shure.co.uk/

SONOR. (2019). SONOR :: AQ2 Studio Set. Retrieved May 21, 2019, from http://www.sonor.com/instruments/drums/aq2-series/aq2-studio-set/

Statista. (2019a). • Statista - The Statistics Portal for Market Data, Market Research and Market Studies. Retrieved June 15, 2019, from https://www.statista.com/

Statista. (2019b). Devices used for music listening in U.S. 2017 | Statistic. Retrieved June 15, 2019, from Statista website: https://www.statista.com/statistics/326004/devices-listening-digital-music-asian-americans/

Teldex Studio. (2019). Teldex Studio Berlin. Retrieved May 24, 2019, from http://www.teldexstudio.de/

Thomann, M. (2019). Yamaha EAD10 Drum Module. Retrieved May 13, 2019, from Musikhaus Thomann website: https://www.thomann.de/at/yamaha_ead10_drum_module.htm

Vafaei, S., Henney, M., & Lamontagne, J.-C. (2016, June 27). AKG K712 PRO Review. Retrieved June 15, 2019, from RTINGS.com website: https://www.rtings.com/headphones/reviews/akg/k712-pro

Winer, E. (2012). *The Audio Expert: Everything You Need to Know About Audio by Ethan Winer*. Focal Press.

Yamaha. (2019). Home - Yamaha - United States. Retrieved May 23, 2019, from https://usa.yamaha.com/index.html

List of figures

Figure 01: Parts of a drumkit (Maislinger, 2018).....08

Figure 02: Principle of pressure (Mistele, 2012).....10

Figure 03: Principle of pressure gradient (Mistele, 2012).....10

Figure 04: Dynamic microphone (Owsinski, 2009).....11

Figure 05: Condenser microphone (Owsinski, 2009).....11

Figure 06: Ribbon microphone (Owsinski, 2009).....12

Figure 07: Common polar patters of microphones (Audio, 2018).....13

Figure 08: The big three panning areas (Owsinski, 2014).....17

Figure 09: Stereo perception (Izhaki, 2012).....17

Figure 10: Position of the hours on a stereo panorama and the equivalent numeric values on the 201-step (Pro Tools, Cubase) and 128 – step (MIDI) scales. (Izhaki, 2012).....18

Figure 11: MIDI ports (Görne, 2014).....21

Figure 12: Yamaha EAD10 Drum Module (Thomann, 2019).....24

Figure 13: Studio Drummer Plug-In – The Session Kit (Native Instruments, 2019).....25

Figure 14: The recorded kit (Maislinger, 2018).....26

Figure 15: Studio Drummer Plug In – The Session Kit (Native Instruments, 2019).....26

Figure 16: Preparing the hardware (Maislinger,2018).....27

Figure 17: Choice of microphones for the live recording session (Maislinger,2018).....29

Figure 18: Snapshot Soundschmiede (Maislinger,2018).....32

Figure 19: Frequency response of the recording room

in the ‘Soundschmiede’ (Mayer, 2018).....32

Figure 20: Reverberation time of the recording room

in the ‘Soundschmiede’ (Mayer, 2018).....33

Figure 21: Reverberation time of the recording room

in the ‘Soundschmiede’ (Mayer, 2018).....33

Figure 22: FFT Waterfall of the recording room in the ‘Soundschmiede’ (Mayer, 2018) 33

Figure 23: ‘The Hall’ – Recording room at Teldex Studio (Teldex Studio, 2019) 34

Figure 24 & 25: Snapshots of the recording for this thesis (Maislinger,2018).....35

Figure 26: Portrait of the drummer (Maislinger, 2019) 35

Figure 27: Screenshot of the folder structure

of the ‘clean’ files within Ableton Live (Maislinger, 2019).....37

Figure 28: Screenshot of the audio to MIDI function of Ableton Live (Maislinger, 2019).....37

Figure 29: “The graph shows devices used by Americans

for listening to music in the United States as of 2017.” (Statista, 2019).....45

Figure 30: AKG – K712 PRO (AKG, 2019) 45

Figure 31: Frequency response of the

AKG – K712 PRO headphones (Vafaei, Henney, & Lamontagne, 2016) 45

Figure 32: AKG – K712 PRO (AKG, 2019) 46

Figure 33: Chart about the points achieved by the participants (Maislinger, 2019).....52

Figure 34: Chart about the ratio of the gender of the participants (Maislinger, 2019).....52

Figure 35: Chart about the ratio of the age of the participants (Maislinger, 2019) 53

Figure 36: Chart about the ratio of instrumentalists to

non-instrumentalists of the participants (Maislinger, 2019) 53

Figure 37: Chart about the ratio of professional to

hobby instrumentalists of the participants (Maislinger, 2019).....53

Figure 38: Chart about the ratio of laywomen and men to

audio specialists of the participants (Maislinger, 2019).....54

Figure 39: Chart about the active music listening hours

of the participants (Maislinger, 2019).....54

Figure 40: Chart about the correctness of the answers

of the first AB question (Maislinger, 2019) 54

Figure 41: Chart about the correctness of the answers
of the second AB question (Maislinger, 2019).....55
Figure 42: Chart about the correctness
of the answers of the third AB question (Maislinger, 2019).....55
Figure 43: Chart about the correctness
of the answers of the fourth AB question (Maislinger, 2019).....56
Figure 44: Chart about the ratio of the opinion based on the sound of
live vs. replaced drumkits of the participants (Maislinger, 2019).....56
Figure 45: Chart about the average score
of each age group of the participants (Maislinger, 2019).....57
Figure 46: Chart about the average score of instrumentalists and
non-instrumentalists (Maislinger, 2019).....58
Figure 47: Chart about the average score of hobby instrumentalists and
non-instrumentalists (Maislinger, 2019).....59
Figure 48: Chart about the average score of hobby instrumentalists and
professional-instrumentalists (Maislinger, 2019).....60
Figure 49: Chart about the average score of laywomen and laymen and
specialists in the audio sector (Maislinger, 2019).....61
Figure 50: Chart about the average score of the groups
of the participant’s active music listening hours (Maislinger, 2019).....62

List of tables

Table 01: Drum set comparison of the NI Studio Drummer Session Kit and the self-recorded live drum kit, data based on (Native Instruments, 2011, 2019; SONOR, 2019) 28

Table 02: Microphone comparison of the NI Studio Drummer Session Kit and the self-recorded live drum kit, data based on (AKG, 2019a; Audio Technica, 2019; Audix, 2019; Coles, 2019; Electro Voice, 2019; Native Instruments, 2019; Neumann, 2019; Schoeps, 2019; Sennheiser, 2019; Shure, 2019; SONOR, 2019; Yamaha, 2019) 30

Table 03: AD conversion and outboard gear of the NI Studio Drummer recording,

data based on (Native Instruments, 2019) 31

Table 04: AD conversion and outboard gear

of the live recording (Maislinger, 2018) 31

Table 05: Table about how many people scored

how many points (Maislinger, 2019) 52

Table 06: Table about the average score of each age group

of the participants (Maislinger, 2019) 57

Table 07: Table about the average score of instrumentalists

and non-instrumentalists (Maislinger, 2019).....58

Table 08: Table about the average score of hobby instrumentalists

and non-instrumentalists (Maislinger, 2019).....59

Table 09: Table about the average score of hobby instrumentalists

and professional-instrumentalists (Maislinger, 2019).....60

Table 10: Table about the average score of laywomen and laymen

and specialists in the audio sector (Maislinger, 2019) 61

Table 11: Table about the average score of the groups

of the participant’s active music listening hours (Maislinger, 2019).....62

List of listings

List 01: List of properties coloring the sound of an acoustic drum kit (Owsinski, 2009) 09

List 02: List of different microphone types (Mistele, 2012; Owsinski, 2009; Winer, 2012) 13

List 03: List of positioning microphones based on (Görne, 2014; Mistele, 2012; Owsinski, 2009; Winer, 2012).....14

List 04: Criteria of a stereo image based on (Izhaki, 2012).....16

List 05: Considerations before replacing drums based on (Izhaki, 2012; Mistele, 2012; Owsinski, 2014; Savage, 2014; Shier et al., 2017; Winer, 2012).....23

List 06: Selected veloci

ties for the drum groove examples (Maislinger, 2019).....36

List 07: Name of the MIDI tracks after the audio to MIDI function

within Ableton Live (Maislinger, 2019) 38

List 08: Parameters of the gate for the kick drum (Maislinger, 2019) 39

List 09: Parameters of the gate for the snare drum (Maislinger, 2019).....39

List 10: Panning parameters for both drum kits (Maislinger, 2019) 39

List 11 Configured parameters for the

kick drum compressor pre-set (Maislinger, 2019).....40

List 12: Configured parameters for the

snare drum compressor pre-set (Maislinger, 2019).....40

List 13 Configured parameters for the Fab Filter Q3 equalizer (Maislinger, 2019).....41

List 14: Configured parameters for the RC 48 Reverb (Maislinger, 2019).....42

List 15: Virtual instruments used for the composed music (Maislinger, 2019) 42

List 16: Naming of the example files (Maislinger, 2019) 43