BACHELOR THESIS

Sound engineers and Guitarists Perception of the Timbre of the Electric Guitar Amplifier as Dependent on Microphone Distance

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Abstract

For this paper it is researched about sound engineers and guitarists perception and preference of the guitar amplifier as the distance between microphone and amplifier is increased. 6 distances from 2 cm to 80 cm was compared with each other in an A/B listening test. The results from the listening test show that both groups identified similar tendencies in spectral perception as what could be predicted from previous research. The groups showed however differences in perception of other parts of the guitar timbre.

Contents

1. Introduction

The “Electro string instrument corporation” made the introduction of the first version of a guitar amplifier in the early 1930s´. These first amplifiers were very simple in design. The first production lines of amps from the company didn´t have neither volume or tone controls and not even an on/off switch and the output was about 10 watts.[1] Other parts of the design were more similar to what we see today such as the preamp being driven by vacuum tubes. In the mid 1950´s the design of the amplifiers became more similar to what we still see today. The output power was increased and the features like spring reverb, tremolo (vibrato on Fender amps) was introduced. Still today the design has not changed dramatically on a standard tube amplifier from those days. Other inventions and revolutions could be mentioned in this part though, for instance the introduction of distortion in the sound became popular. First heard in 1950´s by artists like Chuck Berry but made especially popular by the guitarist Dave Davies from The Kinks. The sound of a distorted guitar is since then a major part in many guitar-oriented genres such as rock and heavy metal.

To record the electric guitar with a directional microphone at a close range, so called close miking can be seen as if not a norm so a common way to do it. It is done in the live environment to prevent feedback issues and in the studio. We can for example se in the book ”The Recording Engineers Handbook” by B. Owsinski that 4 out of 9 standard recording tips with an amplifier consists exclusively of this type of close miking with a directional microphone.[2] As stated by A. Case in “Recording the Electric Guitar- Science and the Myth” another starting approach could be “Shure SM57 microphone, slightly of center of one of the cones of a driver, up close and almost touching the grille cloth”[3] One could also go to out friend Google and see what we find. If one would type the words “recording electric guitar” and see what is found. On Google Image of the first 15 images containing guitar amplifiers in a recording situation, 10 out of them contain techniques that exclusively use close miking.[4]

Before going any further, for this essay the word close miking relates to placing the microphone no more than 20 cm from the amplifier. In the examples given so far the distance has been no more than about 5 cm.

1.1 Purpose

It has so far been stated that it is safe to say that close miking of the guitar amplifier with a dynamic directional microphone is a common way to record it. Recording the guitar amplifier at a close position introduces a couple of qualities or effects to the sound that most engineers and to some extent guitarists are aware of.

1. The proximity effect, which introduces an increase of bass close to the source and a decrease as the distance gets increased. [3] [5]
2. The decrease of level per doubling of distance in the near field is greater than in the “free field” It is also dependent on frequency Which means that small a shift in microphone position will have a greater effect to the timbre of the amplifier up close than further away. [6]

These two points will be explained further in the next section of the essay.

With these two points in mind this bachelors essay it will be researched how the timbre of the guitar amplifier is perceived when the distance between the microphone and amplifier is increased. There will also be a comparison in how the perception is described between guitarists and sound engineers who study at Luleå Tekniska Universitet. A research of preference will also be done, to see if there is a significant difference in preference between guitarists and sound engineers and if it is possible to find a certain position that stands out as the most preferred.

2. Background

On the subject of the guitar amplifier it has recently been conducted research on the spectral directivity of the amplifier.[7][8] It has also been done research where the radiation of a couple of amplifiers is compared with each other.[9] B. Bartlett also wrote a paper 1981 named “Tonal effects of close microphone placement” where the guitar amplifier was included among other instruments.[10] These papers give us a good amount of information where we might conclude it in a simple way; the guitar amplifier sounds very different depending where you place the microphone. In these papers we can see a two tendencies in the amplifiers researched on.

1. The level within a certain frequency band can differ a great deal depending on where you place the microphone. We can for example see that there can be a shift in as much as 10 dB within a 1/3-octave band, just by moving the microphone a couple of centimeters (vertical or horizontal). [7][8]
2. We can see that there is at least in one case an increase in bass, as you get closer to the amplifier. [10]

These papers all have similar methods to get their results. Sine sweep or pink noise is used to feed the amplifier, which is measured with an omnidirectional measurement microphone. So the increase in bass as stated by B. Bartlett [4] is "not due to microphone proximity effect since omnidirectional microphones were used to record the spectra". The increase in bass is in frequencies well below the natural frequencies of the guitar, the low E-string is 82 Hz with a standard tuning. We see that 50 Hz has a boost of at least 4 dB at 3 cm from the amplifier compared to 1 meter away. The bass response in the amplifiers measured in [4,5] is not shown below 250 Hz so it is not possible to see if they to show the same tendency.

The microphones used when these experiments have been conducted have been as stated before omnidirectional measurement microphones. Their true representation of the sound because of their linear frequency response is not however a true representation of how the amplifier sounds when picked up by a more commonly used microphone. A microphone that introduces proximity effect, a directional microphone would probably give a more true representation of the guitar amplifiers as we, recording engineers or guitarists in a recording situation are used to hear it. An experiment that is conducted in this way we can see in "Recording Electric Guitar—The Science and the Myth" by A. Case. [3] The experiment is done by feeding sine sweep to guitar amplifier and recorded with a Shure SM 57. The paper investigates how the frequency response changes as you move the microphone in three different ways. From center to the edge of the cone horizontally as close as possible, from center as close as possible to 60 cm away and when the microphone is angled from on axis to 90 degrees of axis. When the distance is increased a couple of things can be observed. The decrease in level is one; decrease of bass is one, but also the same as we have seen in the researches in the vertical and horizontal plane of the amplifier. In higher frequencies moving the microphone a by just 15 cm the response within some frequency bands can be dramatically changed. [3]

The use of an SM 57 in this research gives a great deal of information of how microphone placement affects the timbre when a dynamic cardioid microphone is used. This is in part because we can see the proximity effect in action which we could not se in the other papers. We can see that there is a big difference in bass frequencies as the distance is increased, for example there is a difference of about 20 dB at 100 Hz.[3] We can see here that the proximity effect is not only bass boost as a directional microphone gets closer; it is also a bass reduction as you move further away as stated by both A. Case [3] and D. Josephson [5].

Though only using the sine sweep or noise (pink or white) does not tell us much about the human perception of the sound of the guitar amplifier it can be a great tool for further understanding it. It can for example provide a great help to understand what frequencies we talk about when we use words like harsh or muddy.

In "Directivities of Symphony Orchestra Instruments" by J. Pätynen 2010 [11] an extensive work has been done to gain knowledge about the radiation of these instruments. Having this knowledge could be of great use in a recording situation and to link this with the papers [3][7][8][9][10] is not far. The difference is that the latter is research done on a guitar amplifier. But when compared like this it should maybe bee seen as an instrument of its own. If looking at it as not only an amplifier with a great variance in spectral directivity we might also consider each amplifier as an instrument of its own. Thus understanding of how it sounds and how it is perceived can only be one step further to be a better engineer or guitarist.

Recording the guitar amplifier at a close distance can as we have seen lead to some spectral anomalies, only due to choice of microphone and the distance to the amplifier. The proximity effect leads without doubt to an increase in bass up close and a decrease in bass with increased distance. The near field of the amplifier leads to an uneven level and frequency response and in the far field there can be comb filtering due to reflections in the room. Should the microphone get really far away we can also start talking about the critical distances where the reverberation of the room will take over the sound from the direct sound of the amplifier.

Since all these distances between microphone and amplifier have distinct spectral qualities it would be interesting to see how engineers and guitarists perceive the timbre of it. We can predict a couple of things to happen by looking at the tings we have learned so far. Having the microphone to close will lead too much bass and perhaps not enough treble. Having the microphone to far away would lead to not enough bass and thus to much emphasis on treble. (The level of treble and high mids would not be increased but it would probably be perceived as such since the bass response is decreasing more than treble.) For easier representation of this prediction or rather how it probably will be perceived see image 1.

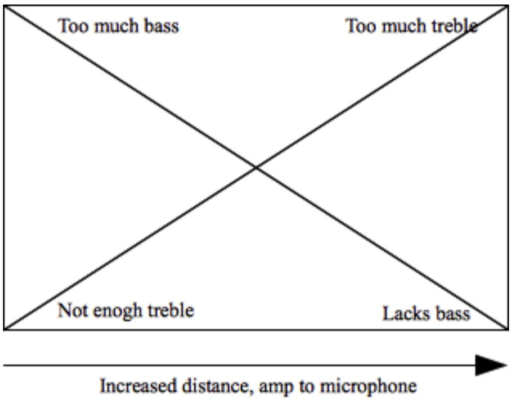

Image 1

To the left we have a closer position and the perceived spectral predictions and the right we have a more distant positions and its perceived spectral predictions. For this essay it will be researched if it is possible to find a distance were the to lines are crossed in the image (it would mean just enough bass and treble), how engineers and guitarists describe the increase in distance and if there is a difference in preference and description between the two groups.

3. Method

To find out how the increase in distance between microphone and amplifier affects timbre and how it is described, a chord progression was recorded with different microphone distances and the stimuli subjected to an A/B test

3.1 Recording of stimuli

To be able to have the same recording on all microphone positions without using 11 different microphones on each designated position, the stimuli was first recorded via D.I via a Radial J48 Phantom Powered Active Direct Box. The microphone signal after the D.I box was fed to a Millennia HV-3D, an eight-channel microphone preamplifier. The signal was then fed to a Line input on a Digidesign Control 24 Console and recorded in Pro Tools HD10 with a session in 24 Bit/ 48 k Hz Sample rate. The guitar chosen was an Epiphone Les Paul Standard with Gibson Humbucker pick-ups. This method made it possible to record each microphone position separately with the exact same performance and with great care taken with the positioning of each microphone, since it then is possible to “re-amp” the signal from the DAW.

The amplifier used for this experiment was a Peavey Bandit 112 recorded with a Shure SM 57. The Peavey Amplifier consists of one 12 - inch speaker cone. The use of this kind of amplifier with only one speaker cone was done so that the sound of one single speaker cone could be researched. Multiple speakers in a single amplifier were avoided since it would introduce effects to the tone that is not desired to research in this particular case. One example is the comb filtering that occurs when the microphone hears the same sound form two or more different sources. Since this could be a topic of it´s own the time limits to this work did not allow it.

The guitar amplifier was then fed the recorded guitar stimuli via a Radial X-Amp Reamping box. What the X-Amp does is that it transforms the low impedance line level signal from a mixing console (in this case a Control 24), a tape recorder, DAW or a line level output from a sound card to a higher impedance instrument level signal. [12]The amplifiers tone was set so a good and clean sounding tone came from the amplifier and no distortion was produced. The amplifier had a choice of three “voicings” on the amplifiers clean channel, “Classic”, “Vintage” and “Warm” each with its own effect on the EQ. The “Classic” mode was selected since it “maintains a standard voicing” from the EQ[13]. The other choices, vintage and warm produced a rather dark tone or one that was easily distorted which was undesirable for this experiment since a clean tone was desired. This was due to that an as neutral tone as possible was wanted so that the listeners would

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focus on the tone itself and not so much on genre. The amplifier was also placed on a table for this session since it is stated by B. Owsinski that “an amplifier...usually sounds better if it´s raised of the floor”. [2]

The signal that recorded then went as follows. First the signal went from an output from the Digidesign Control 24 to the Radial X-Amp that fed the amplifier with correct instrument level. The amplifier was recorded with a Shure SM 57 as stated before and fed to the previous mentioned Millennia HV-3D microphone preamplifier fed back to a line input on the Control 24 and a new channel in the same Pro Tools session as mentioned above.

This was repeated 10 times so that 11 different stimuli were created were the factor that was changed was the distance of the microphone to the amplifier. The distances were close (2 cm from the cloth of the amplifier) 10 cm, 20cm, 30cm, 40 cm, 50 cm, 60cm, 70cm, 80cm, 90cm and 100cm away from the amplifier. The position was: the microphone pointing in the center of the speaker cone.

The volume knobs on the amplifier and the gain on the mic pre were never changed during the session. This resulted quite obviously in a decrease in input level to Pro Tools as the distance between microphone and amplifier was increased. The decision to not change these settings was taken though changing these would change the sound of the stimuli and since only difference in sound of the increased distance was to be researched the settings were remained. The input levels in dB FS Sample Peak into Pro Tools can be seen in Table 1.

To be able to have more spectral information of the sound of the amplifier and gain better understanding of the answers given in the future listening tests, a sine sweep was recorded at each position. This was done with a program called CLIO. The same microphone was used in both the sine sweep and the recording of the stimuli so that CLIO would take a spectral image as close as possible to the stimuli. The frequency response from the stimuli can be viewed in Image 2. As we can see there is a quite even level in the frequencies at 2-6-kHz, which is probably due to reflections from the floor.

Table 1

Distance	Input level dB Fs
Close	-21,1 dB Fs
10 cm	-23,5 dB Fs
20 cm	-28,3 dB Fs
30 cm	-28,9 dB Fs
40 cm	-31,0 dB Fs
50 cm	-32,6 dB Fs
60 cm	-33,8 dB Fs
70 cm	-34,7 dB Fs
80 cm	-35,8 dB Fs
90 cm	-36,6 dB Fs
100 cm	-37,8 dB Fs

The guitar amplifier was placed in a room with the dimensions, 242 cm x 411 cm and 250 cm from floor to sealing. The dimensions from the amplifier to the walls were 141 cm from the back of the amplifier to the wall and 96 cm from the sides of the amplifier to the walls of the room.

To be able to have the microphone pointing at the same point on the amplifier at all positions, with the correct angle, and the correct chosen distance a variety of tools and great care in measuring was needed

First and foremost, the distances were the microphone was to be placed in front of the amplifier was plotted on the studio floor. Then the exact microphone position to the speaker cone was plotted and marked. With the help of a bright lamp and a laser pointer, the center of the speaker cone was plotted. The height of the microphone position from the floor was 95 cm. To be able to have the correct distance from the microphone to the speaker a yardstick and a spirit-level was used. When the microphone was moved back the yardstick was placed on the floor and placed next to the front of the SM 57. The spirit-level was used to make sure that the distance on the floor was the same as the distance from the microphone to the amplifier. To make sure that the microphone always was pointing at the correct point of the speaker cone a laser pointer was used. A positive thing that came out of using SM 57:s is that they have a ribbed design in the front. These thin slots fitted a laser pointer perfectly. So to make sure that the microphone was placed correctly to the speaker cone the laser was quite simply placed in the one of the slots and care was taken so that the laser pointer pointed at the same point o the amplifier every time.

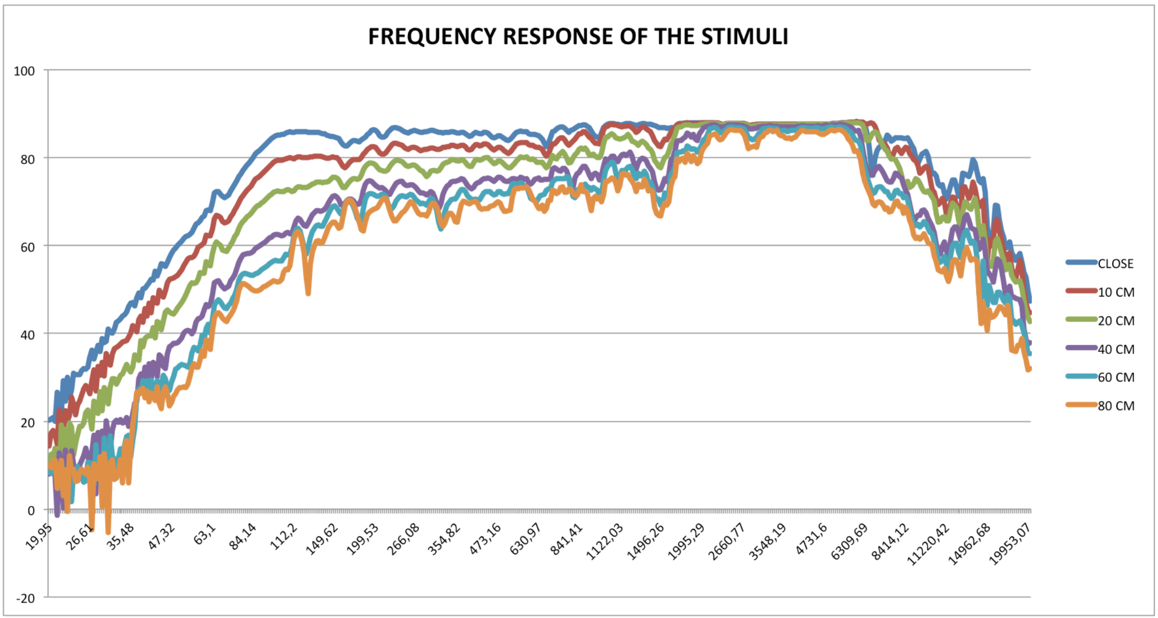

Image 2 (Frequency response of the 6 used microphone positions)

The guitar played a chord progression of the chords C-G-am-F in a way that could be applicable in a pop production. Since no specific preference of a specific genre is to be researched a quite standard chord progression was recorded with a clean tone so no specific knowledge of a genre was needed to do the listening test. If for example a heavy rock riff was to be recorded, a specific tone for this would be needed and perhaps knowledge from the test subjects to be able to judge the sound. So to avoid being to genre specific this sound and this chord progression was chosen.

3.2 Designing the listening test

To find out how the sound engineers and guitarists perceive these stimuli, listening tests were to be conducted. The most suitable test was considered to be an A/B test with the addition that the test subjects will be asked not only to choose which one of A and B their prefer which is the common part. The test subject will first be asked to describe and compare the sounds their hear and then choose preference. This to get the focus on the words and phrases they use to describe the sounds. A problem, which arises in an A/B test with eleven different stimuli, is that it would yield in 55 different A/B pairs. Since each stimulus is roughly 20 seconds long, each A/B round would take at least about one minute to listen to. This would mean that only listen once to each A/B pair would take about 55 minutes. This does not take into consideration that the test subject also will be asked about preference and to describe and compare the stimuli. A more reasonable time would be at least one and a half hour with 55 A/B pairs. So to spare the test subjects time and ears it was decided to cut the stimuli amount to 6. This would yield 15 pairs. And it was calculated that the test would take between 30-45 minutes.

To be able to decide which ones to use without any arbitrary opinions it was decided to use every stimulus with 20 cm distance from each other. But since a big difference in level and frequency was spotted between the 10 cm stimuli and the 20 cm, it was decided to use the 10 cm simuli instead of the 100 cm stimuli. All of the stimuli with 20 cm distance from each other had a difference in level of about 2-3 dB, but the difference between the close microphone position and 20 cm was 7,2 dB. This big difference in level and spectral information from the CLIO readings between the two stimuli gave ground for the decision to use the 10 cm position instead of the 100 cm position. The stimuli chosen for the test were consequently the close position, 10 cm position, 20 cm position, 40 cm position, 60 cm position and 80 cm position. In *Image 2* we can see the spectral representation of each stimuli recorded sine sweep. As we can see there is a big difference between also in the frequency response between the close position and the 20 cm position that validates the use for that one also.

The test itself was conducted in a DAW and the selected one was Logic. The test subjects were to listen to the stimuli with headphones. Since prior research shows that differences in sound sequences are equally perceived in headphones and speaker setups it was for convenience decided to use headphones instead of a specific speaker setup which would tie the test to a specific room and speakers. [14] This would make it easier to find test subjects with limited time to participate on their own schedule.

After the decision of which 6 stimuli that was to be used were made, the next step was to pair them together. Each stimulus was paired with all of the others so that every stimulus would be compared with each other. As stated before 15 pairs were created. The pairs were given their own letter for easy identification as seen in Table 2. To randomize the order in which they would arrive in a session in Logic a technique called Latin Square was used. This way each pair can only arrive at one position in the listening test twice after each pair has been on every position. [15] The Latin Square created for the listening tests is seen in Appendix 1.

As we can see in the Latin Square, pair A only arrives in for example Trial 1 two times in 30 sessions, which was the amount of sessions prepared since more tests than that would give to much data than what would be appropriate for this work.

Table 2

Designated Letter	Pair
A	Close - 10 cm
B	Close - 20 cm
C	Close - 40 cm
D	Close – 60 cm
E	Close – 80 cm
F	10 cm – 20 cm
G	10 cm – 40 cm
H	10 cm - 60 cm
I	10 cm – 80 cm
J	20 cm - 40 cm
K	20 cm – 60 cm
L	20 cm – 80 cm
M	40 cm – 60 cm
N	40 cm – 80 cm
O	60 cm – 80 cm

A problem came up when the pairs in the sessions in Logic were designed. At first the pairs were designed as seen in Table 2 and the first stimuli in the column were always placed on A in the session. The problem that occurred was that a systematic placement of the stimuli gave that the test subjects would probably identify the stimuli in A as always for example have more bass than B. This would probably affect the test since the stimuli would not occur randomly in the session and the test subject would learn this during the test and find a pattern to the test.

To solve this, the order in which the stimuli would arrive on A or B in each round in each test was randomized. This was done with the help of the coin toss application on www.randomize.org[16]. In this application you can set up a coin toss in your own preference. The setup was done as follows; the Swedish coin of 1 Krona was "tossed" 15 times (one for each round in the test). One coin toss would then represent one round in the test. If the coin came up with the king's head up the places of the stimuli would be changed. For example, if the coin toss representing pair A would come up with the king´s head on top the places would be switched and stimuli close would be on B and 10 cm on A. This was repeated for all 30 sessions prepared in Logic. With this way of preparing each listening test it is completely randomized which stimuli to come on either A or B and were in the session it would arrive. It is therefore not possible for the test subjects to learn any specific system to the test because there is none. In Table 4 and 5 it is shown how session 1 looked before and after the randomization of which stimuli would arrive on A or B. The letter x on table 5 represents that the order has been switched between them and is mad for easy representation for the reader. Here after the stimuli will be represented as short name versions, Table 3 shows which name is represented by which stimuli.

Table 3

Stimuli	Short name version
Close	St. Cl
10 cm	St. 10
20 cm	St. 20
40 cm	St. 40
60 cm	St. 60
80 cm	St. 80

Table 4, Session 1 before randomization of A and B.

Session 1	A	B
Trial 1	St. Cl	St. 10
Trial 2	St. Cl	St. 20
Trial 3	St. 60	St. 80
Trial 4	St. Cl	St .40
Trial 5	St. 40	St. 80
Trial 6	St. Cl	St. 60
Trial 7	St. 40	St. 60
Trial 8	St. Cl	St. 80
Trial 9	St. 20	St. 80
Trial 10	St. 10	St. 20
Trial 11	St. 20	St. 60
Trial 12	St. 10	St. 40
Trial 13	St. 20	St. 40
Trial 14	St. 10	St. 60
Trial 15	St. 10	St. 80

Table 5, Session 1 after randomization of A and B.

Session 1	A	B
Trial 1 (x)	St. 10	St. Cl
Trial 2 (x)	St. 20	St. Cl
Trial 3	St. 60	St. 80
Trial 4 (x)	St. 40	St. Cl
Trial 5	St. 40	St. 80
Trial 6 (x)	St. 60	St. Cl
Trial 7 (x)	St. 60	St. 40
Trial 8 (x)	St. 80	St. Cl
Trial 9	St. 20	St. 80
Trial 10 (x)	St. 20	St. 10
Trial 11	St. 20	St. 60
Trial 12 (x)	St. 40	St. 10
Trial 13	St. 20	St. 40
Trial 14 (x)	St. 60	St. 10
Trial 15 (x)	St. 80	St. 10

Since the levels of the stimuli differed a great deal, as seen in Table 6, loudness normalization was conducted prior to adding the stimuli in sessions in Logic. This was done with the help of the Loudness Meter Plug-in R 128 in Pro Tools. Since the recorded level of an instrument does not account for the level it has in a mix it was considered appropriate to normalize the levels of the stimuli. It was also considered that if a couple of stimuli always would reproduced be louder than others it would create a bias for those stimuli. The level chosen for all stimuli was – 23 dB LUFS. In Table 6 we can see every input level of the stimuli used and the level corrections for them.

Table 6

Stimuli	Input level	Level correction
St. Cl	-21,1 dB Fs	-1,9 dB
St. 10	-23,5 dB Fs	+0,5 dB
St. 20	-28,3 dB Fs	+5,3 dB
St. 40	-31,0 dB Fs	+8 dB
St. 60	-33,8 dB Fs	+10,8 dB
St. 80	-35,8 dB Fs	+12,8 dB

3.3 Conducting the listening tests

The listening tests were conducted at Luleå Tekniska Universitet campus Piteå during 14/3-26/3-2014. The 26 test subjects were students at the university, and divided into two groups audio engineers and guitarists. The audio engineers were all students at the audio engineering program and the guitarists were studying music teacher or students at the bachelors in music program. The amount of audio engineers was 16 and guitarists 10. It would have been ideal to get the same number of test subjects from both groups but it was however not possible within the time limits of this study. Two additional audio engineers did the listening test but their tests had to be rejected because one of the faders in the respective Logic session was raised a couple of dB and therefore the stimuli was not level-normalized and the test had to be rejected.

A total of 3 guitarists and 4 audio engineers reported to have tinnitus or a mild form of hearing impairment. Since the answers from these subjects did not differ from the ones without any impairment it was decided to use them anyway. They could without any difference pick out the sonic qualities that separated the stimuli and had views that proved that they were able to form opinions of the stimuli of their own. The impairments of these subjects are therefore considered so mild that they would not affect the result. One other way to make sure that their results were reliable was to see how many subjects that at some time were not able to hear the difference that had hearing impairments. In the guitarist group it was 50/50 and in the engineer group it was eight who at some time were unable to hear any difference and only one reported to have hearing impairments.

The tests were conducted on the premises of Campus Piteå and exclusively in smaller but dedicated control rooms for music mixing. They were therefore quiet in nature and not subject to any visual disturbances or disturbing noises.

The headphone used for every test was Beyerdynamic DT250. The computer used was a MacBook Pro and the DAW used as previously stated was Logic 8.

3.4 Analysis of the listening tests

Two methods to analyze the data will be used, since two types of data come out of the test. To be able to use the words and phrases that come out of the test, Verbal Protocol Analysis will be used. Words and phrases will be sorted into categories in how they are used to describe the sounds. The preferences on each A/B test will be counted and each stimuli will subject do a binominal test. With a binominal test it is possible to see if the preference is statistically significant. The significance level for this essay is 5%, which will be further explained in the next section.

4. Results of VPA

The first part of the listening test was that the subjects were to describe and compare the sounds A and B in their own words. The words and phrases used to describe the timbre of the stimuli were sorted into 7 different categories. In Table 7 the categories are presented and explained.

Table 7

Category	Explanation
Frequency	Used when the timbre is explained to for example lack or more of a specific frequency area. For example "more bass than…"
Value	Used when a stimuli is described to have a negative or positive quality. For example "more pleasant to listen to than" or " to much bass compared to".
Musical	Used when a stimuli is described with musical terms such as fundamentals, or aspects of the guitar itself such as string strumming.
Contextual	Used when a stimuli is put into a context such as fitting in a mix.
Dynamic	Used when the stimuli is perceived as having different dynamic qualities than another such as attack or compression.
Spatial	Used when a stimuli is perceived to have spatial qualities such as roominess or reverb.
Technical	Used when a test subject has tried to with technical terms predict what has been done with the sound. For example EQ or filters.

Since 26 listening tests were conducted it resulted in a large quantity of words and phrases to analyze and translate into English. They were categorized and placed into the correct table as can be seen in Appendix 2.

The translations of words that are not obvious or directly translated from Swedish to English can be seen in table 8. Great care has been taken in this translation to make sure that what the test subject meant to say has been taken in consideration as much as possible.

Table 8, Translations from Swedish to English

Swedish	English
Muddigt	Muddy
Basigt	Bassy
Boomigt	Boomy
Fetare/tjockare	Thicker
Otydligt	Indistinct
Tydligt	Distinct
Varmare	Warmer
Mjukare	Smoother
Mer fylligt	Fuller
Tunnare	Thinner
Mer/mindre kropp	More/less body
Fattigt	Poor
Instängt	Confined
Skrikigt	Garish
Mera "Edge"	Edgy
Vasst	Sharp
"Brightare"	More bright/brighter
Burkigt	Boxy
Rörigt	Messy
Platt	Flat
Skarpt	Harsh
Botten	Low end

Since the two categories Frequency and Value resulted in such a large quantity of words they were once again categorized for a comprehensive overview inside this essay. The new categories were also made to make it possible to look for and perhaps find a pattern in which the stimuli are described. The two new categories were "More of lower frequency information than" and "Lacks lower frequency or more higher frequency information than". Notice that words and phrases from both the Frequency and Value category is possible to use here since its only purpose is to find a possible pattern in how the stimuli is described depending on distance. In table 9,10,11 and 12 these categories are presented. The tables are designed as follows, the column with stimuli is the ones where the phrase is describing and the horizontal rows contain the stimuli that it is compared with. For example the first row in table 9 is describing St. Cl compared with all the other stimuli.

Table 9, More of lower frequency information than. Contains phrases such as, *More bass/low end/thicker/low mid/more body/ muddy/ boomy (Swedish mer bas, botten, fetare, mer kropp muddigt, boomigt) Engineers*

Stimuli	St. Cl	St. 10	St. 20	St. 40	St. 60	St. 80
St. Cl		14	20	15	10	15
St. 10			4	9	7	7
St. 20				11	9	4
St. 40					1	5
St. 60				1		6
St. 80						

Table 10, Lacks lower frequency or more higher frequency information than. Contains phrases such as, *Lacks bass/less bass /thinner than/less low mid, harsher than/ more treble than, (Swedish, saknar/mindre bas, tunnare än, mindre låg mid, skarpare än, mer diskant.) Engineers*

Stimuli	St. Cl	St. 10	St. 20	St. 40	St. 60	St. 80
St. Cl				1		
St. 10	5					
St. 20	2	7				
St. 40	8	8	6		1	
St. 60	8	7	7	1		
St. 80	11	11	8	3	4	

Table 11, More of lower frequency information than. Contains phrases such as, *More bass/low end/thicker/low mid/more body/ muddy/ boomy (Swedish mer bas, botten, fetare, mer kropp muddigt, boomigt) Guitarists*

Stimuli	St. Cl	St. 10	St. 20	St. 40	St. 60	St. 80
St. Cl		9	11	9	12	10
St. 10	1		4	6	9	12
St. 20		1		7	7	9
St. 40					1	7
St. 60						4
St. 80				1	1	

Table 12, Lacks lower frequency or more higher frequency information than. Contains phrases such as, *Lacks bass/less bass /thinner than/less low mid, harsher than/ more treble than, (Swedish, saknar/mindre bas, tunnare än, mindre låg mid, skarpare än, mer diskant.), Guitarists*

Stimuli	St. Cl	St. 10	St. 20	St. 40	St. 60	St. 80
St. Cl			1			
St. 10	4					
St. 20	6	3				
St. 40	9	8	3		3	
St. 60	5	6	3			1
St. 80	5	6	5	6	3	

For the rest of the categories, the number of times a word or phrase came to the respective category was counted and is presented in Table 12 were the engineers and guitarists are compared with each other.

Table 13, amount of times a word or phrase was placed in the respective category.

Category	Engineer	Guitarist
Musical	15	23
Contextual	18	48
Technical	29	3
Dynamic	3	10
Spatial	15	4

4.1 Results of preference

The second part of the listening test was to choose a preference between sound A and sound B. For the analysis, a preferred stimulus given one point and the one that was not preferred was given zero points. Table 13 presents the total points for each stimulus from the sound engineers. The letter X indicates the amount of times where the subjects were unable to identify a difference between A and B.

Table 14

Stimuli	Amount of times preferred
St. Cl	36
St. 10	54
St. 20	48
St. 40	33
St. 60	34
St. 80	22
X	13

The results from the guitarist's tests are presented below in Table 14.

Table 15

Stimuli	Amount of times preferred
St. Cl	28
St. 10	30
St. 20	30
St. 40	19
St. 60	24
St. 80	14
X	5

To be able to present the two groups results in the same graph they were converted to percent, which can be seen in Image 3.

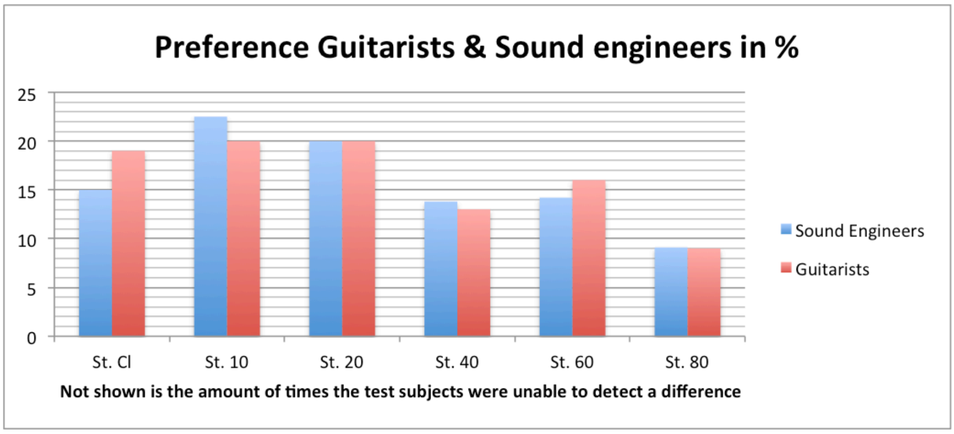

Image 3.

To see if the preference of each stimulus is statistically significant the cumulative probability for each answer was calculated. As already stated the level of significance for this research is 5%, this means that the cumulative probability for each answer has to be less than 5 % to be considered statistically significant.

Before going further some numbers will have to be explained. Since an A/B test was done the probability for each answer is 50/50 or 0,5. The number of trials each stimulus could participate in is 80 for the engineers and 50 for the guitarists test. This is because each stimulus came up 5 times in each test and since 16 tests were made with engineers and 10 with guitarists we get 80 and 50 trials (16*5= 80, 10*5=50). The expected value for the each stimulus would then be 40 for the engineers and 25 for the guitarists.

One example will be given below. We can see that the preference for St. 10 from the engineers equals to 54. To make sure that this is statistically significant, the binomial probability is calculated with the formula below.

$$P(x \text{ "successes"}) = \frac{n!}{x!\,(n-x)!}\, p^x\,(1-p)^{(n-x)}$$

P = probability of times preferred, often called successes.

n= number of trials (80 for engineers and 25 for guitarists

x= number of times preferred

p= probability of "success" in a singe trial, 0,5 since it is an A/B test. ‘

!= factorial

This will give us the probability of 0,0006 and means that it is a 0,06 % chance of this stimulus getting exactly 54 "votes", or being preferred 54 times. To get the cumulative probability, one would simply repeat this calculation with every number over 54 and add the answers. If the answers is less than 2,5 % it is considered to be statistically significant. This is more easily done in Excel with a binomial distributional function. And the cumulative probability for the preference for each stimulus is presented in table 15 and 16. Stimuli with probability marked with * has reached the significance level for this research. Note that the original cumulative probability for each stimulus is half of the value shown but are multiplied with two to compensate for the binomial distribution that means that it is just as likely or unlikely for a stimulus to get for example 78 preferences as only 2 if the number of trials is 80.

Table 16, Cumulative probability for each preference, Engineers

Stimuli	Cumulative probability
St. Cl	0,43
St. 10	0,002*
St. 20	0,09
St. 40	0,14
St. 60	0,21
St. 80	0,00007*

Table 17, Cumulative probability for each preference, Guitarists

Stimuli	Cumulative probability
St. Cl	0,48
St. 10	0,20
St. 20	0,20
St. 40	0,12
St. 60	0,44
St. 80	0,002*

In Appendix 3 and 4 the binomial distribution is presented for engineers and guitarists. For engineers the least value that a stimulus has to get to be considered statistically significant is 51 or the highest for that matter is 29. Results between 29 and 51 are not considered statistically significant results. For the guitarists a stimuli has to reach 35 preferred times to be considered significant or not higher than 15 on the other side.

5. Analysis & Discussion

5.1 VPA

To analyze the results presented from the VPA it is best to divide it into two parts. First we look at the results presented in table 8 through 11.

What we can see is that there is a clear pattern in how the stimuli is described as the distance between microphone and amplifier is increased in both groups of test subjects. As the distance is increased and the proximity effect gets more apparent, in that way that bass roll of is increased as stated by D Josephson[5] the words and phrases tend to describe that spectral tendency. At the three closest positions the words have very much to do with having more bass than the more distant positions. When we get to St. 40, although it is sometimes described as having more bass than St. 60 and St. 80 it is described more as having more treble, lacking bass than the more stimuli. This trend gets more obvious with St. 60 and St.80. This tendency seems to be consistent with both groups of test subjects, the guitarists have a lower amount of answers but they were also fewer in number. Since it is not possible to test the significance of the answers we have to look at them to find a pattern and not definitive answers. In tables 8 through 11 there are some numbers that are not consistent with the pattern, but since it is personal opinions of timbre it would be surprising if the answer from every test subject in both groups would follow the same pattern.

There are some differences between the groups in the use of words, for example the words round and sharp are more used in the guitarist group than the engineer group. Round is used eight times by guitarists and two by engineers and harsh is used eleven times by guitarists but none by the engineers. These words could probably be considered to have similar meaning as smooth and sharp. Which are used more in the engineer group than the guitarist group. Smooth is used ten times by engineers and two by guitarists and sharp is used twenty times by engineers and eleven by guitarists. So we see some difference in vocabulary between the groups but they seem to describe the same thing.

The second part of the analysis of the VPA is comparing the two groups use of words and phrases not dealing with frequencies and values. In these categories we see a larger difference between the groups and tendencies within the groups. Each category will be analyzed separately below.

Musical, this category contains words and phrases about for example the fundamentals of the guitar or how the strings as strummed. One example can be that St. Cl was considered by two subjects in the group sound engineers to have amplified fundamentals compared to St. 10. These are the kinds of words and phrases that the category contains. In this category the guitarists have 23 comments and the engineers have 15. So despite being fewer in number they have more words and phrases in this category.

Contextual, in this category words and phrases describe the sounds in a contextual way for example that it would fit better in a mix. In this category the guitarists have an even greater majority over the engineers. The guitarists have 48 comments in this category over the engineers 18. This shows a similar trend as in the musical category. Guitarists tend to be more likely to or better at listen to a sound and place it into a context of a song or hear musical aspects of it. They are fewer in number but have put much more words and phrases in these categories.

Technical, the words and phrases in this category are directly related to technical aspects of the sound. Examples are comments about specific frequency areas. In this category the tables are turned compared with the last two categories. In those categories we saw that the guitarists seem more likely to describe the stimuli in words concerning those aspects of the sound. In the technical category the engineers write 29 times about it and the guitarists only 3.

Dynamic, in this category the test subjects in the engineer category only write words fitting in the category 3 times, two of them are concerning attack and one is that low frequencies are compressed or attenuated. The guitarist's comments are almost exclusively that one stimuli sound more compressed than the other.

Spatial, this category is the most contradictive category of them all. Eight of the comments from the engineers are "wrong", meaning that a closer position is perceived as having more room sound than a position further away. The rest of the comments are so scattered so that it is not possible to see any tendencies in them. In the guitarist group, there are only 4 comments on spaciousness and they are to scattered and to few to be able to see any tendency among them.

So what do the similar tendency in both groups in the first part and the quite different tendencies of the second part tell us?

In the first part of the VPA analysis it is quite clear that the engineers and the guitarists perceive the increased distance in a similar way. It is indeed some difference in vocabulary but the tendency within both groups show that the increased distance between microphone and amplifier is perceived in about the same way in both groups. As predicted in image 1 and shown in the frequency response of the stimuli in image 2 the bass would decrease and treble would be more prominent. The answers from the listening tests show that both groups of test subjects perceived it in a similar way. No difference between the groups was detected in that area.

A big difference between the groups was found in the categories of context, musical and technical aspects of the stimuli. There was as presented earlier more comments form guitarists in the categories of Musical and Contextual. This shows that we can probably say that guitarists are more likely to think in these terms than sound engineers, especially since the guitarists are fewer in number than the engineers and still have a lot more comments in these categories, particularly the contextual category.

The same tendency but in the other way can be seen in the technical category. The sound engineers seem much more likely to think in technical terms such as specific EQ predictions.

The two remaining categories, dynamic and spatial showed no specific tendency. The words and phrases used for description were to few or to contradictive to be able to see any tendencies.

As stated before looking closer at the frequency response of the different microphone positions in Image 2 a very clear pattern emerges. The level in the area of 2 k Hz-6k Hz remains pretty consistent. Since the stimuli were loudness normalized, the level of the stimuli was raised as the distance increased. Seeing that the level was about the same in this frequency area the level was actually increased instead of normalized in that frequency area. So when the level of the whole stimuli was increased to match for the loss of level in other frequency areas it is not hard to understand why especially St. 80 was perceived as harsh and sharp. The level in the area between 2 kHz and 6 kHz has been raised with 11 dB compared to for example St. Cl. So not only does it have less bass information from the beginning but also it is probably perceived as harsh since the level is increased in an area that our ears are specifically sensitive.

5.2 Preference

The results of the preferred stimuli can be viewed in Table 13 through 16 and it shows that the only stimuli that we with statistical significance say that it is the most preferred is stimuli 2 in the sound engineer group. We can also see that it is statistically significant to say that the least preferred stimulus is stimuli 6 in both groups.

What does this tell us about the relation of microphone distance and the timbre of the guitar amplifier?

Since the three favorites in both groups were in the three closest we can say that having enough bass in the sound is important. We can also see that since the least favorite of the three is the closest that to much bass is not a favorable feature. We might also see that lacking bass or low midrange will lead to the timbre perceived as sharp and thin. This is true within both groups.

The difference between the groups is that we can say with 95 % certainty that St. 10 and thereby 10 cm is the favorite distance from amp to microphone. We can make no such certain statements about the group of guitarists. What this tells us is that in preference the engineers seem to have a little bit more of a consensus about the preferred timbre of the guitar amplifier with this particular sound. The guitarist on the other hand seem to not have the same consensus, but since we saw that they are more likely to put the sounds in a context it is likely that the more wide distribution of opinions could have something to do with it. From these answers we can probably say that they would choose a sound of the guitar amplifier that would fit the specific genre they were playing at the time.

St. 80 was for both groups considered the least preferred sound. From that we can see that even if the preference is quite divided as in the guitarist group, having one only microphone at a 80 cm distance would lead to qualities to the timbre that is unfavorable in most cases. Although St. 80 had some preferred trials so for some cases it perhaps would be a perfect sound. We should not forget that a recording session could and should be a unique way of finding new methods of getting a good sound for the particular session.

Do the answers provided in this report say that sound engineers would always like this particular distance between microphone and amplifier? Is it safe to say that guitarists always would be more likely to say more about musical and contextual parts of the sound and sound engineers about the technical aspects?

No, of course not. The answers given in this report simply states what the test subjects have said and preferred about this particular circumstances. If the room, guitar, amplifier, microphone and test subjects would have been changed or even just one of these, the results could have been completely different. The results should not be taken as truth about recording the guitar amplifier but more as a input to gain more information and understanding of how different microphone distances can be perceived.

Once again it will be noted that since the two groups were not of equal size it is hard to compare them in a good way. Efforts have been made to make this clear during the report.

6. Conclusion

The increase in distance between microphone and guitar amplifier is described by two groups of test subjects, sound engineers and guitarists. The experiment showed that the description of the increased distance was as we might expect from previous research. Which has shown that close microphone placement will lead to an increase in bass and microphone placement further away will lead to less bass. It also showed us that guitarists are more likely to describe the sound of an amplifier with musical and contextual terms. Sound engineers are however more likely to describe the sound with technical terms. Preference for the stimuli could for this research only be stated with statistical certainty for 2 of the six stimuli with in the group of engineers and only 1 for guitarists.

7. Evaluation of method

The method used for this essay seemed to have been able to show what was set out to investigate and answer the research question. There are some decisions made during the course of the work that might have affected the results in some way.

The use of a DAW for the listening test instead of a designated program like STEP might have been a bit intimidating for the inexperienced user since STEP is focused on a user-friendly interface. However since no test subject reported to have any problem with it, the results should be reliable. One negative part of using a DAW for the listening test is that it requires a lot of time consuming work for the author.

The Level Normalization made sure that difference in level should not be a factor in which the stimulus was perceived and preferred. What it however did was that it actually amplified the effects of the distance microphone placements as discussed earlier.

8. Further research

For further research it would be interesting to see how much the results are depending on the specific products used in this research. Readers interested in the results given could for example change microphone or guitar and see if the results change. A comparison between different microphones and directivity's would also be welcome to gain further understanding of the timbre of the guitar amplifier.

9. Acknowledgments

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Also thanks to all the test subjects that participated in the listening test.

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Appendix 1

Session	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9	Trial 10	Trial 11	Trial 12	Trial 13	Trial 14	Trial 15
1	A	B	O	C	N	D	M	E	L	F	K	G	J	H	I
2	B	C	A	D	O	E	N	F	M	G	L	H	K	I	J
3	C	D	B	E	A	F	O	G	N	H	M	I	L	J	K
4	D	E	C	F	B	G	A	H	O	I	N	J	M	K	L
5	E	F	D	G	C	H	B	I	A	J	O	K	N	L	M
6	F	G	E	H	D	I	C	J	B	K	A	L	O	M	N
7	G	H	F	I	E	J	D	K	C	L	B	M	A	N	O
8	H	I	G	J	F	K	E	L	D	M	C	N	B	O	A
9	I	J	H	K	G	L	F	M	E	N	D	O	C	A	B
10	J	K	I	L	H	M	G	N	P	O	E	A	D	B	C
11	K	L	J	M	I	N	H	O	G	A	F	B	E	C	D
12	L	M	K	N	J	O	I	A	H	B	G	C	F	D	E
13	M	N	L	O	K	A	J	B	I	C	H	D	G	E	F
14	N	O	M	A	L	B	K	C	J	D	I	E	H	F	G
15	O	A	N	B	M	C	L	D	K	E	J	F	I	G	H
16	I	H	J	G	K	F	L	E	M	D	N	C	O	B	A
17	J	I	K	H	L	G	M	F	N	E	O	D	A	C	B
18	K	J	L	I	M	H	N	G	O	F	A	E	B	D	C
19	L	K	M	J	N	I	O	H	A	G	B	F	C	E	D
20	M	L	N	K	O	J	A	I	B	H	C	G	D	F	E
21	N	M	O	L	A	K	B	J	C	I	D	H	E	G	F
22	O	N	A	M	B	L	C	K	D	J	E	I	F	H	G
23	A	O	B	N	C	M	D	L	E	K	F	J	G	I	H
24	B	A	C	O	D	N	E	M	F	L	G	K	H	J	I
25	C	B	D	A	E	O	F	N	G	M	H	L	I	K	J
26	D	C	E	B	F	A	G	O	H	N	I	M	J	L	K
27	E	D	F	C	G	B	H	A	I	O	J	N	K	M	L
28	F	E	G	D	H	C	I	B	J	A	K	O	L	N	M
29	G	F	H	E	I	D	J	C	K	B	L	A	M	O	N
30	H	G	I	F	J	E	K	D	L	C	M	B	N	A	O

Appendix 2

Tables for every category for words and phrases used by the two groups of test subjects

Sound engineers

Stimuli 1 (Frequency)	
More bas than 2	5
More bas than 3	5
More bas than 4	1
More bas than 5	2
More bas than 6	3
More low mid than 2	2
More low mid than 3	3
More low mid than 4	2
More low mid than 5	1
More low mid than 6	1
Muddy compared to 3	1
Muddy compared to 4	3
Muddy compared to 5	1
Muddy compared to 6	1
Less treble than 2	1
Less treble than 3	1
Boomy compared to 2	2
Boomy compared to 3	2
Boomy compared to 4	1
Boomy compared 6	2
Lower low end than 4	1
Thicker low end than 3	1
Thicker than 6	1
Ringing frequency compared to 4	1
Midrange peak compared to 4	1
Lacks bas compared to 4	1
Darker than 3	1
Darker than 4	1

Stimuli 1 Value	
Indistinct compared to 4	2
Indistinct compared to 5	1
Indistinct compared to 6	1
Warmer than 3	2
Warmer than 4	2
Warmer than 5	1
Warmer than 6	1
Smother than 3	3
Smother than 4	1
Smother than 5	2
Smother than 6	1
Pleasant to listen to compared to 5	1
Pleasant to listen to compared to 6	2
Too much bas compared to 2.	2
Too much bas compared to 3	1
To much bas compared to 5	1
To much bas compared to 6	3
To much low mid compared to 5	1
To much low mid compared to 6	1
Sharp	2
Pleasant low frequency info	1
Good low mid compared to 3	1
Unpleasing low mid compared to 2	1
Fuller than 2	1
Fuller than 4	2
Fuller than 5	1
Fuller than 6	1
More body than 4	1
A bit to dull compared to 3	1
More depth than 2	1
Good and different midrange compared to 2	1
Good and different midrange compared to 4	1
Calmer than 3	1
Calmer than 5	1
More mature than 4	1
Sounds messy compared to 3	1
Uneven timbre compared to 3 (bas frequencies sticks out)	1
Even and good timbre compared to 5	1
Heavy in bas in a good way compared to 2	1
Loses a bit of treble but a nice timbre compared to 3	1
Well balanced compared to 5	1

Stimuli 1 Musical	
Amplified basnotes compared to 4	1
Amplified fundamentals compared to 2	2
Amplified fundamentals compared to 5	1
Amplified fundamentals compared to 6	1
Fuzzy fundamentals compared to 4	1

Stimuli 1 Contextual	
Very close mot my ideal sound compared to 3	1
Spot on, perfect balance between bas and treble, compared to 4	1 same test subject as above. (session 10)

Stimuli 1 Spatial	
More room than 2	1
More room than 3	1
More room than 4	1
More room than 5	1
More room than 6	1

Stimuli 1 Technical	
Sounds as if something is boosted compared to 2	1
Sounds as if something is boosted compared to 5	1
Sounds as if something is boosted compared to 6	1
Sounds scooped compared to 5	1
Boosted bas frequencies compared to 2	1

Stimuli 2 Frequency	
Uneven bas compared to 6	1
More bas than 3	2
More bas than 4	3
More bas than 5	4
More bas than 6	3
More low end than 5	1
More low end than 6	1
More low mid than 5	1
More low mid than 6	1
More treble than 1	1
Thinner than 1	1
Nasal	2
Muddy compared to 3	1
Boomy compared to 4	1
Boomy compared to 5	1
Boomy compared to 6	1
Sounds thin compared to 1	1
Ringing frequency in the end	1
More body than 4	2
Lacks body compared to 1	1
Lacks bas compared to 1	2
Well balanced frequency range compared to 1	2
Well balanced frequency range compared to 4	1
Well balanced frequency range compared to 5	2

Stimuli 2 Value	
More pleasing to listen to than 1	1
Good low end compared to 6	1
Indistinct compared to 5	1
Indistinct compared to 6	1
Less messy than 1	1
Sounds poor compared to 1	1
Sounds confined	1
Sounds more pleasing than 4	1
Sounds more pleasing than 5	1
Warmer than 3	1
Warmer than 4	2
Smoother than 6	1
More full than 5	1
To much bas compared to 4	1
To much bas compared to 5	1
To much bas compared to 6	1
More distinct than 1	1
More distinct than 5	1
Unpleasing High-mid	1
Unpleasing bas compared to 3	1
Sounds more natural than 1	1
Better spectral balance than 1	2
Better spectral balance than 3	1
Better spectral balance than 6	2
Better low mid than 4	1
Well balanced bas-mid-treble compared to 5	1
Well balanced bas-mid-treble compared to 6	1
Better balance between High and low mid compared to 1	1
More edge than 6	1
Sounds calmer than 1	1
Sounds more complete than 3	1
Sounds much better than 6	1
A bit annoying but better spectral balance than 5	1
Sounds nice compared to 6	1
More natural than 3	1
Sharp	2
Garish	1
Unpleasant	1
Hurts the ears	1

Stimuli 2 Musical	
Better string strokes than 6	1
Better fundamentals than 5	1

Stimuli 2 Contextual	
Close to the ideal timbre compared to 6	1
Closer to the ideal timbre than 1 but lacks bas	1
Dirtier than 1 in a good way.	1
Too much bas to be played with a bas-guitar	1

Stimuli 2 Spatial	
More room than 3	1
More room than 6	1

Stimuli 2 Technical	
Sounds like treble have been boosted	1
Sounds boosted	1

Stimuli 3 frequency	
A lot of energy on one frequency area	1
Round	1
Heavy in low mid compared to 5	1
Indistinct treble compared to 1	1
Better spectral balance than 6	1
More bas than 4	3
More bas than 5	1
More bas than 6	1
More low end than 4	3
More low end than 5	3
More low end than 6	1
Less low end than 2	1
More low mid compared to 4	1
More low mid than 5	1
More body than 4	1
More body than 5	1
Better spectral balance than 1	1
Better spectral balance compared to 2	1
Well balanced spectral balance compared to 4	1
Nasal	1
More nasal than 2	1
More presence information than 2	1
More high mid than 6	1
Thin & lacks bas	1
Brighter than 2	1
Rich in overtones	1
On the verge of being sharp	1
Sounds more open and rich in treble than 1	1
More treble than 2	1
Sharper than 2	1
Sharp but with some low end	1
Less bas than 2	1
Harsh compared to 2	1
Limited bandwidth	1
Less bas and more midrange makes it sound more boxy than 2	1
Boxier than 5	1

Stimuli 3 Value	
Somewhat messy compared to 6	1
Distinct compared to 2	1
Distinct compared to 4	2
Sounds flat compared to 1	1
Better sounding low mid/bas than 5	1
Sounds hard compared to 1	1
Sounds smooth compared to 4	1
Boomy compared to 6	1
Fuller than 4	1
Fuller than 5	1
Fuller than 6	1
Warmer than 4	1
Warmer than 5	1
Sounds nice compared to 4	2
Sounds more neutral than 4	1
More pleasant to listen to than 5	1
Sounds poor compared to1, but is preferred for being more distinct.	1
Preferred 3 because of its wider frequency range	1
Sounded better than 2	1
Good sounding midrange compared to 2	1
To much treble compared to 1	1
To thin compared to 2	1
Sounds digital, anonym, and sterile compared to 6	1
Very unpleasant, hurts to listen to.	2

Stimuli 3 musical	
A bit more string strokes than 6	1
More string strokes than 4	1
Clearer sound of the pick than 1	1

Stimuli 3 Contextual	
Sounds unnatural but with a possible way of use	1

Stimuli 3 Dynamics	
Low frequencies sounds attenuated or compressed compared to 1	1
Has more punch (attack) in the lower frequencies than 4	1

Stimuli 3 Spatial	
Disturbing reverberation	1
Messy reverb compared to 2	1
More 3-dimensional than 5	1
Feels closer than 4	1

Stimuli 3 Technical	
Sounds as 1 with HPF	1
Sounds as if it has been HPF and boosted treble	1
Unwanted boost in the lower treble	1

Stimuli 4 Frequency	
Harsher than 1	1
Boxier than 1	3
Boxier than 3	1
Boxier than 6	1
More low end than 5	1
More low mid than 6	1
More low end than 6	3
Less bas than 1	1
Less bass than 2	2
Lacks bas compared to 1	3
Lacks bas compared to 3	2
Thin compared to 1	1
Thin compared to 2	3
Thin compared to 3	2
Sharp compared to 1	1
Sharp compared to 3	1
More body than 6	1
Less sharp compared to 6	1
Brighter than 3	2
Brighter than 5	1
More treble than 1	1
More treble than 2	1
More treble than 3	1
More overtones than 5	1

Stimuli 4 Value	
Sounds confined compared to 1	1
More interesting midrange than 3	1
Sounds cleaner than 6	1
Cleaner than 3 but in an unwanted way	1
Warmer than 6	1
More distinct than 5	1
Crispier than 6	1
Less powerful than 5	1
More pleasant to listen to than 1	1
Has a tender timbre.	1
More distinct treble than 2	1
More distinct treble than 3	1
Has more edge than 2	1
Sounds more even and nice compared to 1	1
Has a weird timbre	1
Sounds better than 1	1
Messy compared to 3	1
Indistinct compared to 6	1
Non appealing treble	1
Confined and boxy treble	1

Stimuli 4 Musical	
Clearer string strokes than 6	1
Clearer string strokes than 5	1

Stimuli 4 Contextual	
Fits probably better in a context than 3	1
Has a “telephone” type of sound compared to 3	1
Had a vintage feel (positive)	1

Stimuli 4 Technical	
Sounds like treble has been boosted.	2
Sounds like a boot around 4 k Hz has been made	1
Sounds LF cut compared to 1	1

Stimuli 5 Frequency	
Well balanced frequency response compared to 6	1
More high mid than 2	1
More treble than 1	3
More treble than 2	1
More treble than 3	1
Thinner than 1	2
Thinner than 2	1
Thinner than 3	1
Lacks bas compared to 1	2
Lacks bas compared to 2	2
Lacks bas compared to 3	3
Fuller than 4	1
Fuller than 6	1
Brighter than 3	1
Less bass than 1	1
Less low end than 2	1
Lacks balance between Bas-mid- treble	1
Basier than 6	3
Rich in overtones	1
Sharp	4
Sharper than 4	1
Sounds poor compared to 2	1
More even frequency range than 4	1

Stimuli 5 Value	
Garish compared to 2	1
Garish compared to 3	1
Indistinct compared to 2	1
Distinct compared to 1	3
Distinct compared to 2	1
Sounds better than 2	1
Warmer than 6	1
Almost painful for the ears	1
Sounds charming and "Old Fashioned"	1
Sounds a bit gnällig	1
To much high midrange compared to 2	2
More pleasant to listen to than 4	1
Cleaner than 6	1
More HIFI than 6	1
Less bass/mid than 2 in a good way	2
Tighter than 3 (positive)	1
Sounds clearer than 2, proximity effect?	1
Smother than 6	1

Stimuli 5 Musical	
Lack string strum compared to 4	1

Stimuli 5 Contextual	
Sounds more natural than 1	1
Would fit better in a mix than alone.	1
Has a "Beatles sound to it. "	1
Preferable indie sound to 1	1
Has a "older sound"	1

Stimuli 5 Spatial	
Suitable reverb compared to 4	1
Sounds as if a reverb has been added compared to 4	1

Stimuli 5 Technical	
Percieved as filtered in an unwanted way	1
Sounds boosted	1
Sounds like HPF cut compared to 1	2
Sounds like HPF cut compared to 3	1
Unnaturally boosted at 1-2 kHz	2

Stimuli 6 Frequency	
Thinner than 5	2
More treble than 5	1
Less low end than 1	4
Less low end than 4	1
Lacks bas compared to 1	3
Lacks bas compared to 2	1
Thin compared to 1	2
Thin compared to 2	5
Thin compared to 3	4
Thin compared to 4	1
Lacks body compared to 2	1
Lacks low end compared to 2	1
Lacks low end compared to 3	1
Less bas than 3	1
Less bas than 5	1
More treble than 2	1
Hard treble compared to 2	1
Harder high mid than 5	1
Brighter than 1	1
Nasal compared to 2	2
Nasal compared to 3	2
Nasal compared to 4	1
Rich in mids	1
Good spectral balance compared to 3	1

Stimuli 6 Value	
Distinct compared to 1	1
More distinct treble compared to 1	1
Clearer than 1	1
Clearer than 3	1
Rounder and pleasant timbre compared to 4	1
Feels amateurish	1
Sharp	6
More tender than 1	1
More tender than 3	1
More tender than 5	2
Sounds unnatural compared to 2	1
Unwanted frequency ringing in the end	1
Sounds bad compared to 2	1
Sounds unnatural	1
Sounds poor compared to 2	1

Stimuli 6 Musical	
Twangy compared to 1	1

Stimuli 6 Contextual	
Has an “Old school” sound on a good way	1
More usable than 1	1
More usable than 3	1

Stimuli 6 Spatial	
Messy reverb	1
Less room than 1	1

Stimuli 6 Dynamic	
More attack than 5	1

Stimuli 6 Technical	
Sounds as if the guitar has a band pass filter (makes the guitar less muddy compared to 2)	1
Sounds HPF	3
Sounds amplified around 500 Hz	1
Scooped in low mids compared to 3	1
Boosted in high mids	2

Guitarists

Stimuli 1 Frequency	
More full than 2	2
More full than 4	2
More full than 5	3
More full than 6	2
More bas than 2	4
More bas than 3	3
More bas than 4	3
More bas than 5	6
More bas than 6	4
More low end than 2	1
More low end than 3	2
More low end than 6	1
More mid than 3	2
More mid than 5	1
Thicker than 4	1
Thicker than 5	1
Muddy compared to 6	1
Boomy compared to 6	1
Uneven frequency response	1
More treble than 3	1
Nasal	1
More rumble than 4	1

Stimuli 1 Value	
Distinct bas and treble compared to 4	1
Indistinct compared to 6	1
Clear treble compared to 6	1
Rounder than 2	1
Rounder than 3	1
Rounder than 4	1
Rounder than 5	1
Warmer than 3	1
Warmer than 4	2
Rounder treble than 6	1
More pleasant to listen to than 2	3
More pleasant to listen to than 4	2
More pleasant to listen o than 3	1
More pleasant to listen to than 5	2
More pleasant to listen to compared to 6	2
Indistinct treble compared to 5	1
Pleasing midrange compared to 2	1
Pleasing bas and treble	1
Indistinct compared to 3	1
To much bas compared to 6	1
To much bas and treble compared to 3	2
To much low mid compared to 2	1
Feels more compact than 3	1
More compact then 6	1

Stimuli 1 Musical

Clearer string strum than 3	1
Clearer string strum in higher strings	1
Smooth string strum in lower strings than 5	1
Includes a frequency that makes the guitar more out of tune compared to 2	1
More string noise than 3	1
The fundamental on the G-chord rumbles to much	1
Rumbly fundamentals compared to 4	1
Fundamentals sticks out more than in 5	1

Stimuli 1 Contextual	
"Was more as you want it, more stereo feeling(?)" compared to 3	1
More character than 3	1
More complete than 6	1
Reaches further in the sound image than 5	1
Comes closer in the sound image than 3	1
Sounds like in a bedroom compared to 5	1
Does not deliver the correct energy compared to 4	1

Stimuli 1 Spatial	
Feels wet	1

Stimuli 1 Technical	
Boosted midrange frequency	1

Stimuli 2 Frequency	
More low end than 3	1
More low end than 5	1
More bas than 4	1
More bas than 5	3
More bas than 6	5
Fuller than 4	1
Fuller than 5	4
Fuller than 6	2
Less bass than 1	2
More mid than 6	2
Muddy compared to 4	1
More treble than 1	1
Thin	1
Sharper than 1	2
Sharp	1
Less treble than 4	1
More lustrous treble 6	1
More even frequency response than 4	1
More nasal than 1	1
Nasal	1

Stimuli 2 Value	
More distinct bas and treble than 1	1
More distinct bas and treble than 4	1
Distinct treble	1
More distinct treble than 1	1
Good amount of bas and treble	1
Low end makes it more airy than 5	1
Warmer than 1	1
Warmer than 3	1
Warmer than 4	1
Warmer than 5	1
Warmer than 6	1
Smoother than 3	2
Smoother than 4	1
Smoother than 6	1
Rounder than 4	1
Rounder than 6	1
Sounds cleaner than 3	1
More well balanced than 1	1
Sounds more living than 3	1
Broader frequency response than 5 but still flat	1
A bit more annoying than 1	1
More pleasant to listen to than 3	1
More natural than 6	1
More clear than 1	2

Stimuli 2 Musical	
Sharp string strumming	1
Better mix of the frequency spectra of the guitar than 4	1
Clear fundamentals compared to 5	1

Stimuli 2 Contextual	
Sounds bigger than 4	1
Preferred because it would fit better in a sound image than 1	1
Sounds flatter than 4	1
Has a more interesting sound even than 1 is more pleasant to listen to	1
Gets closer in the ear compared to 4	1
More present and living than 1	1
Feels more far away than 3	1
Clear "sound"	1

Stimuli 2 Dynamic	
Sounds a bit compressed	2
More compressed than 6	1
More compressed than 4	1

Stimuli 3 Frequency	
Thicker than 2	1
Thicker than 5	1
Thicker than 6	3
More bas than 4	2
More bas than 5	4
More bas than 6	3
More full than 4	3
More full than 6	2
More low end than 4	1
More high mid and treble than 1	1
More treble than 1	3
Harsh compared to 1	1
More even frequency range than 1	1
Broader frequency response than 5	1
Harsher midrange than 2	1
More sharp than 2	1
More nasal than 1	1
More nasal than 2	1

Stimuli 3 Value	
Good amount of bas compared to 5	1
Smoother than 6	2
Rounder than 5	1
Warmer than 4	1
Warmer than 5	2
Warmer than 6	1
Sharper and more metallic than 1	1
Clearer than 2	1
More even than 6	1
More living than 2	1
More living than 4	2
Sounds compact	1
A bit annoying but distinct	1
Sounds more complete than 6	1
More distinct than 1	2
More distinct than 5	1
Distinct treble compared to 5	1
More pleasant to listen to than 6	1

Stimuli 3 Musical	
Harsh string strumming	1
Some frequency gets more present that makes the guitar sound out of tune compared to 5	1
High notes are more present than on 1	1
Clearer G-chord than 2	1
Sounds flatter than 5 especially present on the G-chord	1

Stimuli 3 Contextual	
Has an “in your face sound”	1
Sounds bigger than 6	1
Sounds “rock n roll mid boosted” compared to 1	1
Unusual guitar sound	1
Would fit perhaps fit better in a context but 2 is more pleasant to listen to	1
Has more character than 5	1
Feels closer in a sound image than 2	1
Feels closer in a sound image than 4	1

Stimuli 3 Dynamic	
Sounds compressed	2
More dynamic compared to 2	1

Technical	
Sounded phase flipped	1

Stimuli 4 Frequency	
Less low end than 1	1
More treble than 1	3
More treble than 2	4
More treble than 3	3
More treble than 5	2
More bas than 6	3
More mid than 6	1
Thinner than 1	2
Thinner than 2	1
Sharper than 2	2
Fuller than 6	1
Thicker than 5	1
Thicker than 6	2
Harsh	2
Harsher than 1	1
Harsher than 2	1
Harsher than 5	1
Thin	1
Full	1
Brighter midrange	1
More nasal than 1	2
Has an annoying midrange peak	1
Good low end and treble compared to 2	1

Stimuli 4 Value	
More metallic than 2	1
Clearer timbre than 6	1
Sounds richer than 2	1
Clear and crisp but lacks low end	1
More living than 5	1
Nice bas and treble compared to 3	1
Nice crispy sound	1
Sounds flat compared to 2	1
To garish compared to 2	1

Stimuli 4 Musical	
String strumming is less prominent than in 2	1
First chord sounds better than in 6	1

Stimuli 4 Contextual	
Would sound better in a rock band than 3	1
Better rock sound than 1	1
Sounds more mono than 2	1
Sounds like an old transistor radio	2
Sounds smaller than 1	1
More character and personality than 2	1
More personality than 3	1
Bigger than 2	1
Preferred 1 but 4 would be better in a mix	1
Sounds more suitable in a context than 1	1

Stimuli 4 Dynamic	
Sounds compressed compared to 3	1

Stimuli 4 Spatial	
Sounds dry	1

Stimuli 5 Frequency	
Lacks low end compared to 1	1
More nasal than 1	1
More nasal than 2	1
More treble than 2	1
More treble than 3	1
More treble than 6	1
Thin compared to 1	2
Thin compared to 2	3
Thin compared to 3	1
Harsh compared to 1	1
Harsh compared to 2	1
Harsh compared to 3	1
More bas than 6	3
Boxy midrange compared to 3	1
More midrange than 4	1
More distinct midrange than 6	1
More even frequency response than 3	1

Stimuli 5 Value	
Rounder compared to 6	1
Sounds more complete than 6	1
Sounds more even than 6	1
Nice and distinct treble compared to 6	1
More distinct than 1	1
Sounds flat compared to 2	1
More natural than 4	1
Clearer bas than 4	1
More treble than 3 in a good way	1
More distinct and clear compared t 2	1
More living than 2	1
More pleasant to listen to than 1	1
Indistinct bas compared to 2	1
Better energy than 2	1
Better energy than 3	1
Clearer than 3	1

Stimuli 5 Musical	
Higher strings sounds boxy compared to 4	1

Stimuli 5 Contextual	
Sounds more suitable in a mix than 2	1
More usable sound than 1	1
Sounds like it is further back in the sound image	1
Has more character than 3	1
Sounds higher up in the head phones than 3	1
Lack of bas takes it back in the sound image	1
Nice country twang	1
More suitable for the type of playing compared to 1	1
More suitable for the type of playing than 2	1

Stimuli 5 Spatial	
Dryer than 3	1

Stimuli 5 Dynamic	
Sounds compressed compared to 1	1
Sounds compressed compared to 3	1

Stimuli 5 Technical	
Sound band pass filtered compared to 2	1

Stimuli 6 Frequency	
Lacks bas compared to 1	1
Lacks bas compared to 4	1
Lacks body compared to 2	1
Lacks midrange compared to 5	1
Harsh compared 1	1
Harsh compared to 2	1
Harsh compared to 3	1
Harsh compared to 4	2
Thin compared to 1	1
Thin compared to 2	1
Thin compared to 3	1
Thin compared to 4	1
Thinner than 5	1
Sharp compared to 1	1
Sharp compared to 2	1
Sharp compared to 3	3
Sharp compared to 4	1
Sharp compared to 5	1
More treble than 1	2
More treble than 2	1
More treble than 3	1
More treble than 4	1
Lacks low end compared to 2	2
Lacks bas compared 4	1
Lot of midrange compared to 3	1
More narrow frequency spectra than 2	1

Stimuli 6 Value	
Distinct compared to 1	2
Smoother than 4	1
Smoother than 5	1
Sounds flatter than 5	1
Sounds poor compared to 2	1
Has a more garish character	1
More distinct than 1	1
Sounds boring compared to 2	1
Distinct and good amount of warmth and crispiness compared with 3	1
More brilliance than 4	1
Better energy than 2	1

Stimuli 6 Musical	
Top notes in the chords comes out better in the chords than I	1
Smoother chord strumming than 4	1
Would probably cut through a sound image better than 3	1
Distinct higher strings	1

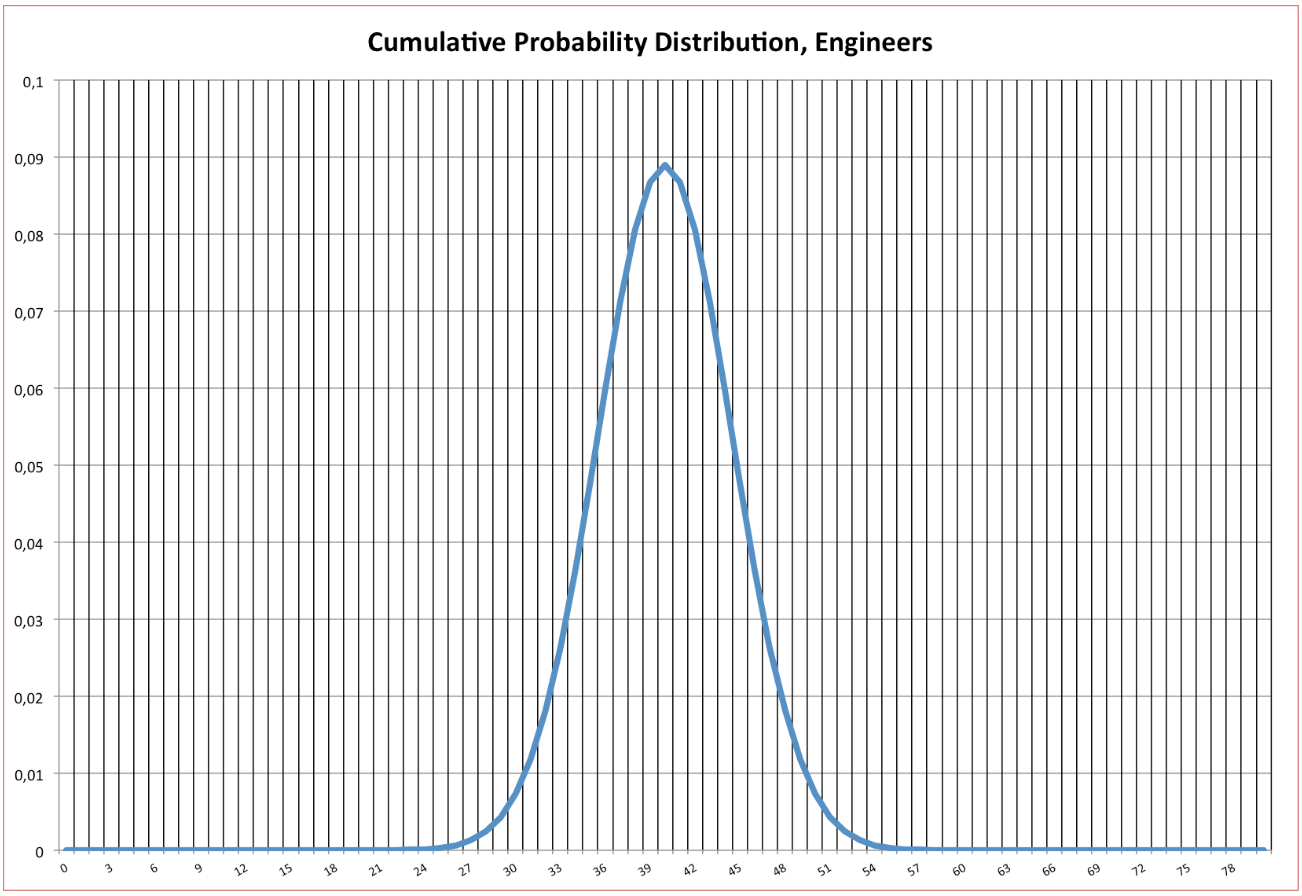
Stimuli 6 Contextual	
Sound a bit broken, but cool!	1
Has more of a stereo feel than 4	1

Sounds like an old radio compared to 1	1
Sounds like an old radio compared to 2	1
Would fit better in a context than 1, invites to overdubs.	1

Stimuli 6 Spatial	
Dryer than 2	1

Appendix 3

Cumulative Probability Distribution Sound Engineers



Appendix 4

Cumulative Probability Distribution, Guitarists