GITEC Listening Experiment: Tone Woods in Electric Guitars

Tilmann Zwicker, Manfred Zollner, Kurt Härtl, Wolfgang Hönlein & Jörg Gebhardt

1. Introduction:

In spring 2016, the GITEC association (German-language homepage: http://gitec-forum.de/GitecWP/) ran a listening experiment (German-language report here: https://gitec-forum.de/wp/gitec-community/hoerversuche/) The objective was to gather evidence regarding the question whether there is an audible sound difference (in the electric sound) between electric solid body guitars made of different body and neck materials but of otherwise identical construction. Specifically, we were interested whether or not guitar players actually hear a corresponding sound difference

Both in literature and in various places in the Internet the question whether the kind of wood used for an electric solid body guitar makes an audible difference is discussed controversially - and emotionally charged.

Many hold the opinion that there is - for example - a clearly audible sonic difference when listening to the sound taken from the output jack of a guitar with a body made of ash compared to the sound of an otherwise identical guitar with a body made of alder. One will find statements such as: "Ash exhibits a bright, well defined sound whereas alder gives a mid-rangy, girth-y sound." Likewise, many follow the opinion that a neck made of solid maple generates - in the electric output of a solid-body guitar - a more clear, precise but also colder sound when compared to a neck with a glued-on rosewood fretboard.

On the other hand, there are also many voices that state that there is no audible difference.

Again, it is important in this context to keep in mind that it is the electrically amplified sound that is evaluated, and not the (rather weak) acoustic sound generated by a solid body guitar.

Also, the present experiment and its evaluation do not claim in any way to conclusively answer the general question: "How do differences in the material used to construct electric solid body guitars manifest themselves?" Much less do the authors seek to give any guidance regarding the issues:
- What is worth the effort?
- What's good and bad?
- How much effort should be put into the construction of a solid body guitar?

2. General considerations and approach

With the present experiment we try to obtain - using a reasonably simple method - a first impression of whether the amplified sounds of solid body guitars constructed with different materials can be differentiated. Therefore, we do not investigate how specific materials may sound. Rather, with this first approach we want to see whether any difference can be heard in the first place and how significant and reliable this listening experience is. We focus exclusively on the listening aspect i.e. the auditory event. Clearly, there are other aspects of importance in the framework of a musical instrument such as look and feel, price, or image and reputation. These are not considered at all in the present discussion.

One highly important aspect for us was using a blind-test-method. In most comparisons found in the Internet, one knows/sees which instrument is which and this may influence the judgment.

To keep the experiment attractive to the subjects and to avoid stretching their patience, we did not use too many test sounds and repetitions of these sounds. This meant that we would get a limited statistical significance of the results. On the other hand, we could expect that if there were any clear discriminability between sounds generated by instruments of different wood materials (as postulated by many sources in literature and the internet), we would obtain an unambiguous result even with relatively few repetitions of test sounds.

3. The experiment:

For this experiment we used sounds available on the internet. Pete Lacis, an American guitarist, has published an ample number of tests, comparisons and considerations on his website (http://www.petelacis.com) on the topic of electric guitars. In one of these comparisons (http://www.petelacis.com/2010/07/08/alder-vs-swamp-ash-maple-vs-rosewood-and-a-neck-swap-the-definitive-comparison-with-audio-clips/), he has made numerous recordings of Stratocaster-type instruments made by Suhr Guitars. What makes these recordings particularly interesting is that he played as similarly as possible not just on the two instruments at his disposal (one with an alder body and a solid maple neck, the other with an ash body and a maple neck with rosewood fretboard) but also swapped the bolt-on necks so that all-in-all sounds generated by guitars of 4 different neck/body-combinations could be heard: alder/maple, ash/rosewood, ash/maple and alder/rosewood. All other mechanical and electrical components of the guitars were identical, and the settings on the guitars and the amp used were also kept the same.

For the listening experiment we selected a number of more undistorted sounds from the sound files posted by Pete Lacis, and cut short samples from them which were presented in pairs to the subjects. The editing of the samples was done such that musically conclusive riffs resulted despite the shortening. The sounds are still available on the GITEC Webpage (https://www.gitec-forum-eng.de/listening-experiment-tone-woods-in-solid-body-electric-guitars/), where the whole experiment can be downloaded and run.

Three run-throughs using different sequencing of the test sounds were presented to the subjects. The combinations alder/maple vs. alder/rosewood and alder/maple vs. ash/maple were presented twice, the combinations ash/maple vs. ash/rosewood and alder/rosewood vs. ash/rosewood were presented 3 times.

On top of these pairs of sounds generated with instruments of different body/neck-wood-combinations, we also presented further pairs of sounds (which we designate - in the present context - "control-sounds"):
- pairs of sounds generated by the same combination of materials, i.e. the respective guitar was compared to itself,
- repetitions of sound-pairs i.e. the same combination of audio files was presented a second time.

These comparisons "with itself" were inserted with the intention that audible differences between actual different instruments could be identified more clearly, and also as control pairs to be able to assess the significance and reproducibility of the test results of individual subjects.

To keep the subjects alert, we inserted a very different sound pair (designated "alert sounds" here) in every run through of the experiment:
- in runs 1 and 3 there was a pair of identical audio files where the 2nd file was however changed via an EQ of +3 dB at 725 Hz and 2 kHz, respectively
- in run 2 there was a sound pair consisting of different riffs - i.e. not a sound suitable for pure sound comparison but one raising attentiveness.

The task of the subjects was very basic: the perceived audible difference (if any) between the sounds in a sound pair had to be rated in its strength on a scale between "0" (no difference perceived) and "10" (very strong difference perceived). As mentioned above, subjects were not asked to determine the respective corpus or neck materials but merely to make a statement regarding the perceived sound difference.

The subjects were instructed to disregard differences (if any) in the playing between the presentations and to focus only on the perceived sound. It was not possible to determine how successful the subjects were in following this instruction within the framework of the present experiment (see also the discussion below). Further and more extensive experiments would be necessary to look into this.

26 visitors of the GITEC website chose to participate in the experiment.

There are two main questions for the evaluation:
- Do subjects perceive a difference between the presented sounds, i.e. do they perceive a sound difference between the 4 guitars (4 combinations of 2 necks and 2 guitar bodies)?
- If yes, how reliable and reproducible are these perceptions?

4. Results

Fig. 1 shows the individual results given by the 26 subjects. The 4 sections correspond to the 4 comparisons offered:
- alder body w/maple fretboard vs. alder body w/rosewood fretboard
- ash body w/maple fretboard vs. ash body w/rosewood fretboard
- alder body w/maple fretboard vs. ash body w/maple fretboard
- alder body w/rosewood fretboard vs. ash body w/rosewood fretboard

The upper two sections (in black) thus correspond to comparisons between sound generated by guitars of different neck materials while the lower two sections (in blue) refer to comparisons of sounds stemming from guitars of different body materials.

For each subject there is a (vertical) column: the 26 columns are ordered along the horizontal axis. On each column (ranging in value from 0 to 10) the dots show the perceived sound differences for the respective body/neck combination

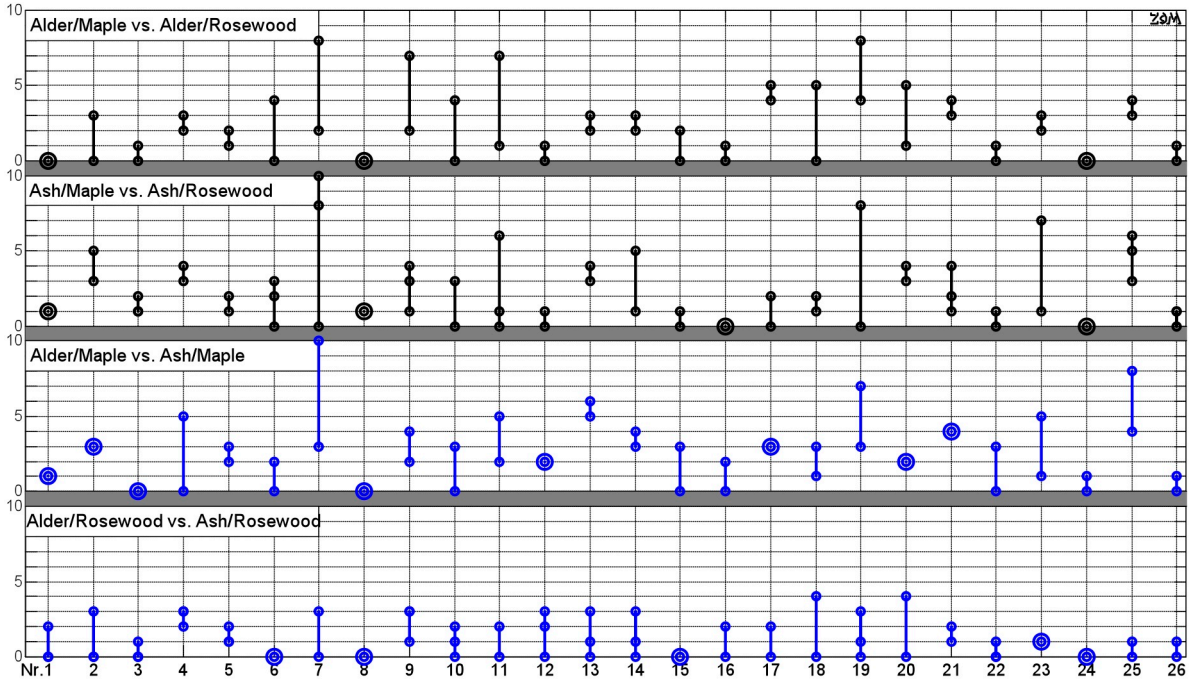

Fig.1: Perceived sound differences (on a scale between 0 and 10) between two guitars for 26 subjects. Four comparison variations (see text)

Fig. 2 depicts the results given by the 26 subjects for the "control" sounds.

In the uppermost field the results for the case where the same guitar was presented twice (first section: magenta dots).

The second field relates to the repetition of test-sound pairs. In this diagram it is not the difference perceived by the subject but the difference between the differences perceived, i.e. “difference perceived for the first presentation minus difference perceived for the repetition of the same test-sound pair”. Looking at these results allows for conclusions regarding the repeatability and the dependability of the perceptions: if the “difference of the perceived differences” is small (close to 0), the subject indeed has the same perception and gives a dependable statement. If, on the other hand, this value is significantly above 0, the subject generates different results despite the same stimuli, and hence shows lower dependability.

In the lower two fields of the Fig. two different musical riffs were presented (third section: orange crosses), or different EQ's (forth section: black dots) were involved rather than different body and neck materials.

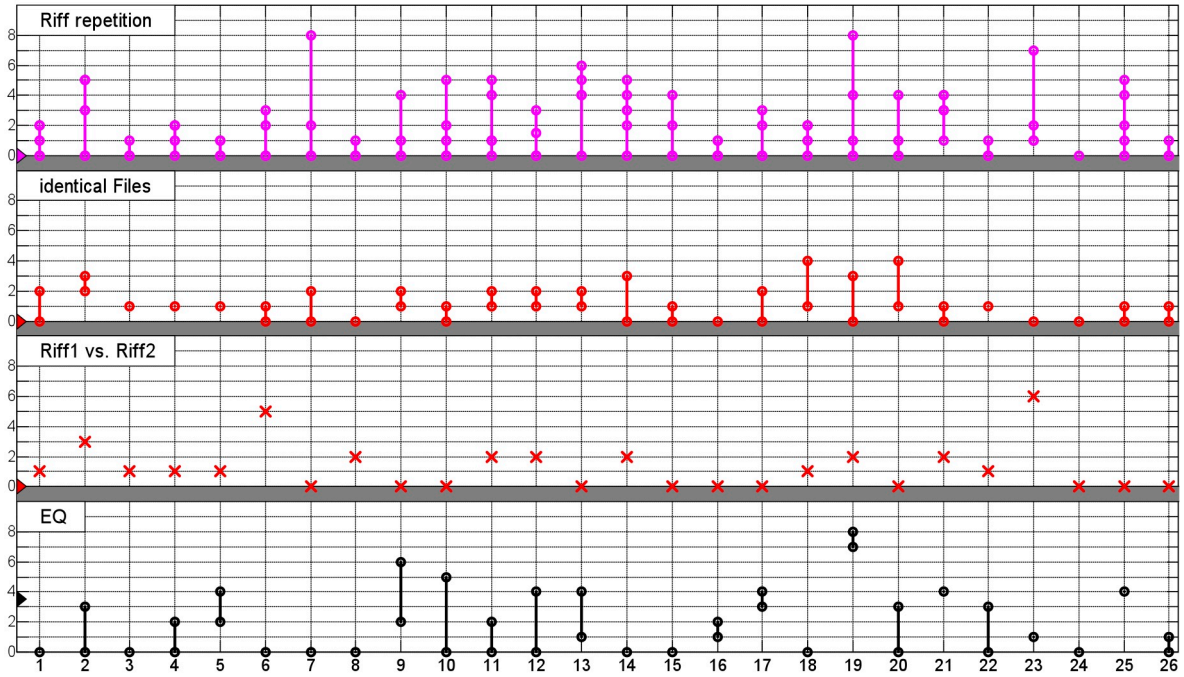

Fig 2: Perceived differences between
- sounds generated by the same guitar,
- repetition of the same test-sound pair (the difference between the two corresponding perceptions is given),
- two different riffs, and
- two different EQ settings (flat vs. +3 dB at 725 Hz and 2 kHz, respectively) for 26 subjects

5. Evaluation of the results

It is clear from Fig. 1 that some subjects hear little or no difference in the sounds generated by guitars made of different woods - they rate the differences at or near "0". Examples are the subjects no. 1, 3, 5, 8, 16, 22, and 26. However, there are at least as many subjects who do clearly hear a difference - in some cases even a very drastic one (i.e. they rate the sound difference at up to "10"). Examples are subjects no. 7, 9, 11, 18, 19, 20, 21, 23, and 25. For the subjects who detected strong differences in sound, the variability of this result was generally high: they heard a strong difference in the presentation but failed to do so when the same presentation was repeated (or vice versa).

Looking at Fig. 2 we observe something quite interesting: although the same guitar is compared to itself ("riff repetition", magenta dots), a number of subjects detect differences of - in some cases - considerable magnitude.

Fig. 2 is also interesting in that it shows that a change in EQ ("EQ", black dots) is not necessarily perceived as a sound difference! 7 subjects rate the associated comparison as sounding the same. This aspect was however not followed up in the present experiment.

There seems to be a general trend when comparing Figs. 1 and 2 that those subjects who hear strong differences between guitars of different woods also hear strong differences when comparing the same guitar (i.e. same wood). Some of them also show a higher variability in their perceptions (see the 2nd section of Fig. 2).

This 2nd section of Fig. 2 shows a basic variability of the subjects: when the same stimulus-pair is repeated, almost all subjects have a different perception. This variability generally has a range of in the order between “1” and “4” on the scale of 0 – 10.

Also worthy of consideration is that in the lowest line of Fig. 1 (i.e. the comparison of ash body with rosewood fretboard and alder body with rosewood fretboard): the perceived sound differences were generally rather small compared to the other comparisons. Incidentally, the perceived differences in one part of the control group (comparing the same guitars) were generally larger.

6. Discussion

It may be helpful to first take a look at the somewhat surprising results shown in Fig. 2. They require additional and special consideration. For the second section "identical files", the same sound-file combination - in other words the **exact same difference in the stimulus** - was presented twice to the subject who was asked to rate the perceived difference.

That many subjects detect a difference between physically identical presentations shows that there is considerable variance in the perception. When asked to rate a difference again after a certain time and after other events, subjects seem to have a tendency to hear a larger or smaller difference. To reduce or even eliminate this variance from the results of a listening experiment would require many more run-throughs of the same experiment so that a statistically more stable evaluation is possible. We chose not to extend the experiment in such a way because of the more exploratory character of the present investigation and to match the efforts necessary to the available capacity.

For the present experiment, the results of the comparison of the same stimulus-pairs can in any case be helpful to obtain an idea about the variance-level generally inherent in all the results we have gathered. Subjects rate physically identical sound-pairs to be different up to a value of 4 on the given scale between 0 and 10. It would thus seem reasonable for the comparison of the other stimuli (i.e. the other sections of Fig. 2 and especially the results from Fig. 1) to only take results into consideration as meaningful where a rating of 4 and up has been given. This range would also seem to cover the "repeatability" of the comparisons, i.e. it would seem unrealistic to expect that subjects can dependably (re-)detect any difference they rate with less than "4".

As just implied, with the few repetitions of the stimulus-pairs, a deep statistical analysis of the present results is not warranted. Nevertheless, the results would seem to indicate a tendency that those subjects who hear significant differences between guitars made from different woods do so only with a relatively poor reproducibility.

According to Fig. 1, more often than not the perception of a large sound difference is not repeated for the second presentation (or vice versa). In the figure, this is indicated by long lines between the dots. The longer the line, the more a big perceived difference could not be heard when the same two sounds were presented again. For optimal reproducibility, there would be no lines but only "double dots" (as showing e.g. for subject 8). Very few subjects show a high difference rating (level 4 and up) and at the same time repeat this rating. Such subjects do however exist at least for some of the comparison scenarios: they are in particular subjects 13 (third section of Fig. 1), 17 (first section of Fig. 1), 19 (first section of Fig. 1), 21 (first and third sections of Fig. 1), and 25 (second and third sections of Fig. 1).

Taking into consideration Fig. 2 (first - upper - section), it shows that subjects 13, 19, 21, and 25 also perceive a substantial difference (level 4 and up) in sound when the same guitar is presented. In this comparison, they also show considerable variability of the result.

One would think that for these comparisons of the same guitar with itself, the perceived differences should be very small - in fact they ideally should be "0" with a full reproducibility, i.e. there is only a single combined dot at "0". As we have seen from the discussion of the second section of Fig. 2 above, such variance-free results cannot realistically be expected.

Since the same guitar is repeatedly played for the results of the first section of Fig. 2, the sound files are not identical - it is impossible to play the same riff, or line on a guitar twice without any differences in the electrical signal even if such differences may be minute. It is thus possible that subjects lock in not on differences in the sound of the guitar but on differences in the playing. Also, the sound is to a large extent dependent on the playing - and thus even if great care is being taken to play in the same way, minute playing differences may filter through into the sound.

Nevertheless, if there are such differences, they cannot play a generally significant role since none were universally detected by the subjects. It is safe to say that Peter Lacis did a very good job playing the sound samples and achieve a good similarity between the playing on the different guitars.

Overall, it seems that for most subjects there is no certainty in their perception of sound differences, if they perceive a substantial difference at all.

Comparing again Figs. 1 and 2, it is clear that for most subjects the strength of perception of a difference of sounds generated by guitars of different wood is not at all or not significantly higher than the strength of perception of differences in sound generated by the same guitar or repetitions of same test-sound pair. Whether there are physical differences in the guitars listened to or not, the sounds are not perceived as different to an extent that would clearly filter through. In other words: there is no indication that the subjects could with any certainty distinguish between sounds generated by guitars made of different wood. Rather, they hear differences in sounds generated by guitars of the same wood construction, as well - and sometimes these differences are perceived as stronger than the ones resulting from guitars of different construction. For the latter scenario, subjects no 2, 7, 13, 19, 23 and 25 may serve as example. This is a strong indication that the wood used for the construction of the guitar plays only an insignificant role in the generation of the electrical sound.

Only subject no. 4 seems to reproducibly hear a (smallish) difference between guitars made of different woods **and** at the same time reproducibly hears no difference between sounds generated by the same guitar. To some extent this also applies to subject no. 17, albeit only in terms of the difference perceived for guitars of different necks mounted on the same (alder) body. Whether these isolated reproducible results are statistically reliable is not clear. Answering this question would require significant further effort and more investigations.

7. Conclusions

The results of the present experiments do **not** support the hypothesis mentioned in the introductory section above: that one can conclusively and immediately distinguish between the (electrical) sound of solid body guitars made of different body and neck materials. In fact, the data here point in the opposite direction: there seem to be no significant audible sonic differences that could be attributed to the wood materials of body and neck of a solid body guitar.

Having stated this result, it is highly important to point out again the fact that the present investigations aim purely at the **listening** experience. It is very clear that the total **playing** experience on guitars of different construction can be vastly different. The player may have a totally different sensation from one instrument to the next - possibly in a number of dimensions, e.g. as already mentioned look and feel, price, or image and reputation. This will translate into a subjectively different sound perception as well, and have a highly positive (or negative) effect on the artistic expression. However, it would seem that this connection has nothing to do with any physical "sound of the wood" or the use of "tone-woods" in electric solid body guitars. The wood used in solid body guitars would seem to make - in itself - no audible difference. This is in sharp contrast to other parameters playing a role for a solid body electric guitar, in particular pickups and electric circuitry that can make a very big difference in the perceived sound.

Additional remark:
In this investigation, we have seen that statistical aspects such as reproducibility and certainty of perceptions are of considerable importance. In the framework of this report, we did not have the time or capacity to look into this issue with any depth. We are however considering picking up the associated questions, either in a continuation of this discussion applying more statistics to the results of the present experiment, or in the framework of new experiments.