Analysis of Sounds Caused by a Golf Club Hitting the Ball

The sound of a golf club hitting a golf ball can be quite exhilarating, provided that the ball was hit correctly. A good golf club is expected to create the characteristic sound that tells the golfer that he made a good hit. Any new golf club that does not create this desirable sound, even with a good hit, would not survive in the market. Acoustics may not be the predominant factor a golfer relies on when choosing his clubs, but it still subconsciously influences the perception of quality.

The characteristics of the right sound can be easily determined with the analytic possibilities of ArtemiS. In the following, three sounds recorded with three different golf clubs hitting the ball are examined. The sound of the first club (Golfclub1) is subjectively rated the best. The sound of the second club (Golfclub 2) is slightly worse, but still considered good. The sound created by the third club (Golfclub 3) is considerably worse. Of course, the golf ball used has an influence on the sound as well. However, in this Application Note, only different golf clubs are compared, not different balls.

Recording the Sounds

Figure 1: Golfer with BHS

For an aurally accurate recording of the hitting sounds, a suitable solution is the BHS (binaural headset) in connection with the four-channel frontend SQuadriga. The golfer wears the BHS like a headphone (see figure 1), and its integrated microphones can be used to record the hitting sound. An optional windscreen is available for the BHS, which can be used to reduce wind noise that may be present on the golf course. The BHS is connected to a SQuadriga unit operated in stand-alone mode, which is excellently suited for this kind of outdoor recordings due to its handy size, the built-in battery and its flash memory card. The golfer can easily carry the device while playing without being obstructed.

Level Analysis

A simple, but useful analysis is the calculation of the sound pressure level. Recently, golf clubs made of titanium have attracted attention. With this kind of club, golfers can not only achieve higher distances, but these models also create louder hitting sounds than conventional golf clubs. In some cases, these sound events even reach a level where hearing can be damaged. While the level analysis cannot be used to determine the quality of the sounds created by different clubs, it can be used to identify clubs that might cause damage to the user's hearing.
Figure 2 shows the level analysis of recordings of three hitting sounds.
All of the sounds have a high peak in the sound pressure level curve; yet it is unlikely that they would cause hearing damage, since the maximum sound pressure level is below 120 dB (SPL). Club 3, which has the worst sound, also has the highest sound pressure level, but this is not necessarily an indicator of sound quality. The level analysis should mainly be used to exclude the possibility of hearing damage, as it does not allow reliable conclusions regarding the perceived sound quality. To determine the quality, other analyses are better suited.

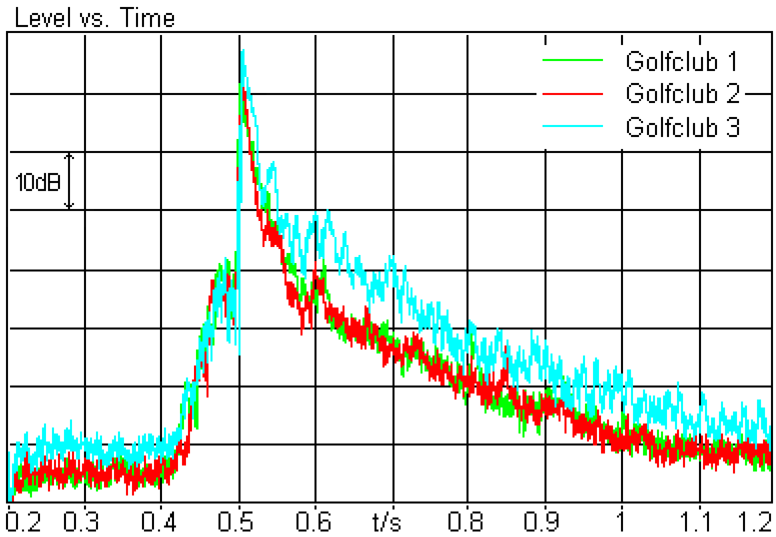

Figure 2: Level analysis of hitting sounds of three different golf clubs

FFT Analysis

With the averaged FFT analysis, the frequency spectrum curve can be determined. Figure 3 shows the FFT analysis of the three recordings. It is obvious that the sound of the third golf club has a prominent tonal component (between 1.6 and 2.5 kHz), which is not present in the other two sounds. This component is very dominant and has a strong influence on the sound quality. The frequency distribution in the sound of the third golf club is unbalanced.

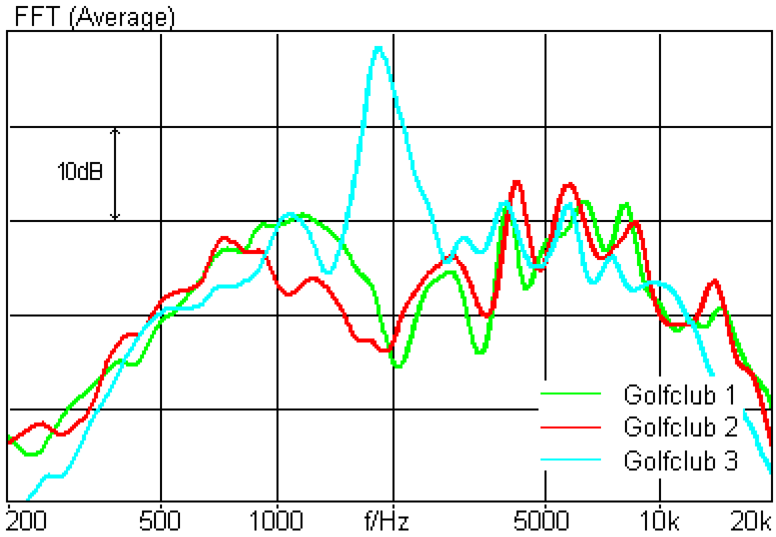

Figure 3: FFT analysis of hitting sounds of three different golf clubs

Time-dependent n^th Octave Analysis

Another important aspect for the sound analysis is the temporal development of the sounds. It can be examined with time-dependent analyses, whose results are plotted against time. Figure 4 shows the results of a 12^th octave analysis versus time. The frequency resolution of the n^th octave analysis (finer at lower frequencies, coarser at higher frequencies) matches the frequency resolution of the human ear better than an FFT analysis, which has an equidistant frequency distribution. Furthermore, a time resolution of 2 ms was chosen for the analysis, which matches the time resolution of human hearing.

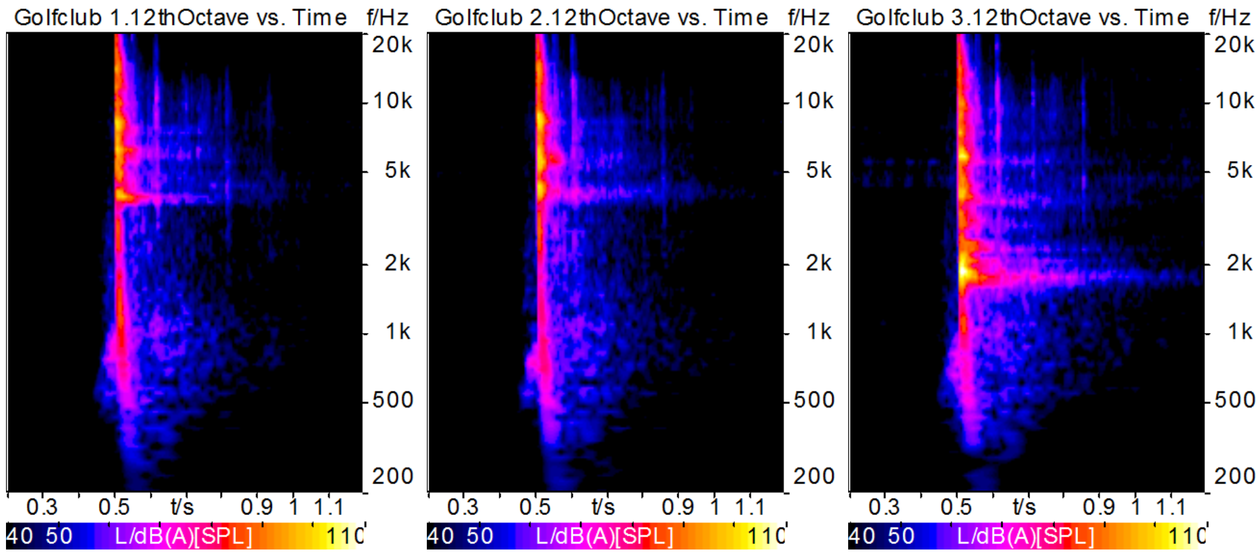

Figure 4: 12^th octave analysis of hitting sounds of three different golf clubs

The comparison of the three sounds shows a small difference between the first and second golf club, and a significant difference to the third club. The tonal component is not only prominent in the frequency spectrum, but it also fades out more slowly than the other frequency components, which attributes even more to the bad sound quality.

Specific Loudness Analysis vs. Time

Loudness analysis examines sound events in accordance to the loudness perception of human hearing. Figure 5 shows a loudness analysis of the hitting sounds versus both time and frequency group (frequency resolution equivalent to human hearing).
This analysis shows the difference between the sounds very clearly. Between 10 and 17 Bark, the sound of the third golf club has a particularly high loudness curve compared to the two other sounds. Also, this analysis again shows the longer reverberation of the tonal component in the third sound.

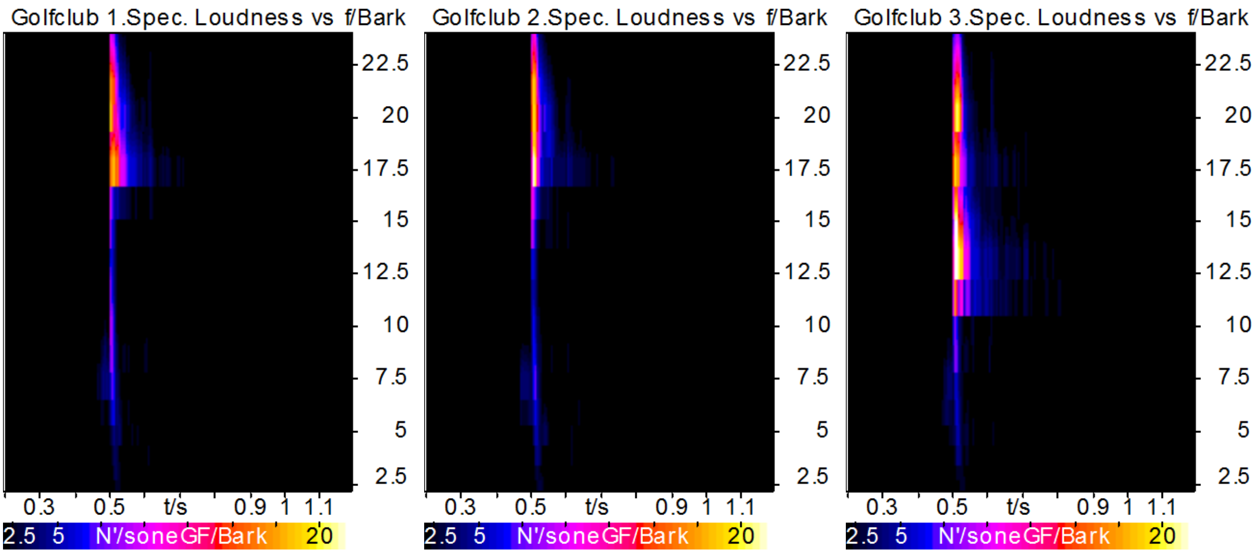

Figure 5: Specific loudness analysis of hitting sounds of three different golf clubs

This longer reverberation can be caused, for example, by insufficient damping of the shaft and could be improved by choosing a better material. This change might also reduce the tonal component. An additional possibility is changing the structure of the club head in order to achieve a more balanced frequency distribution and thus a better sound quality.

The examination shows that the sound quality of golf club sounds can be visualized quickly and easily with the analysis functions provided by ArtemiS. The analysis results shown above clearly reflect the quality differences perceived by listeners and can yield suggestions how to improve the quality.

Notes

For the analyses presented in this Application Note, you need the ArtemiS base version (code 4600), the ArtemiS Psychoacoustics module, ATP 02 (code 4602) and the ArtemiS Octave Analysis module, ATP 04 (code 4604).

Do you have questions for the author? Contact us at: imke.hauswirth@head-acoustics.de.
We are looking forward to your feedback!