A Comparison of the Variable Acoustics of Two Foley Studios for Sound Effects Recording

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Introduction

The sound effects and voices that are heard in motion pictures are often replacements or additions of sounds recorded in a Foley Studio. In this type of studio, named after Jack Foley, the pioneer in movie sound effects recording, many objects like wooden floors and doors are present to record sounds from (see figure 1). These recordings need to sound as they are heard in the real world or even as an exaggeration of that world. Therefore it should be possible to create a lot of different acoustical conditions in a Foley Studio. The requirements are not very straightforward though, because there is few literature about Foley Studio design, also because there are few Foley Studios. To determine the proper room acoustical requirements, the variability of acoustical properties of two existing Foley Studios have been compared: one typical studio and one with a good reputation.

Figure 1: A piece of a wooden staircase inside a Foley Studio

The Foley Studios

Both studios have a rectangular shoe-box shape with a large projection screen for the video on one side and a small stage for the sound engineer on the opposite side. In between the stage and the screen, the Foley 'stage' is situated: in the sidewalls, different kinds of doors and windows are provided as well as a small sink, a bathtub, a kitchen and even half a car. On the floor, different kinds of materials are used like wooden plank, concrete, sand and straw for the Foley artist to walk on. Also, there is a table for all kinds of stuff that the Foley artist brings with him to record sounds from. From this point of view both studios are more or less identical.

In both studios different acoustical provisions are introduced to control and vary the acoustics of the room (see figure 2):

- The typical studio with a volume of 385 m^3 has a perforated screen with partly sound absorbing material behind it. In front of the three other walls, heavy curtains are hung that can be opened and closed by remote control. When the curtains are open, they are still exposed in the room. In the ceiling panels are provided with a reflective and absorbing side that can be turned by remote control as well.

- The studio with a good reputation has a volume of 340 m^3. In this studio the perforated screen is fully sound absorbing. The three other walls are made sound diffusing by the use of large wooden half cylinders. In front of the sidewalls, heavy curtains are hung that can be opened and closed by remote control. When the curtains are open, they are still exposed in the room. The triangular shape makes the ceiling sound diffusing, some sound absorption is added to the ceiling as well.

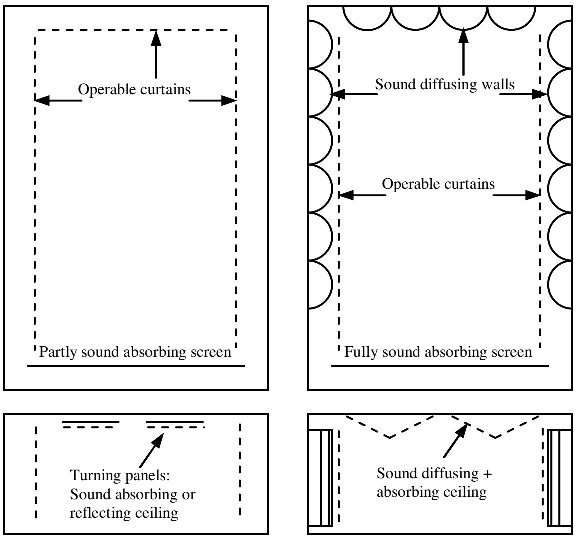

Figure 2: Schematic acoustic design in floor plans (upper drawings) and sections (lower drawings) of the typical studio (left) and the studio a with good reputation (right)

Typical Foley recording setups

To be able to investigate the acoustic properties of a Foley Studio, it is important to understand the use of the space by recording technicians. Some typical Foley recording setups have been investigated:

A) In many movie scenes a sound is heard inside a room. In real life, reflections, echoes and reverberation are added to the sound generated by the sound source. To imitate this in a recording studio, one often records a mix of the direct sound and the diffuse sound (sometimes referred to as the dry sound and the ambient sound). This is done by placing at least one microphone close to the sound source and another microphone further away from the sound source.

B) It is also common practice to add late reverberation with an effects processing device, instead of recording the diffuse sound with a second microphone. To be able to do so, the reverberation time of the recording room has to be less than half the reverberation time of the effects processing device [1]. In this case, the direct sound is recorded with a close microphone, while the room has as little reverberation as possible. But often not only the direct sound is recorded. The Foley maker can choose to record close to a sound reflecting wall (sometimes referred to as the 'hot' side of the room), adding natural early reflections to the recording.

C) In other movie scenes, the recording needs to sound as if one is standing outdoors. In this case no reverberation may be heard in the recording, but there may be some reflections from the floor or echoes from the surroundings. If the room can not be made 'dead' enough itself, a typical setup that is often used for recording outdoor voices is a sound absorbing tent with one or two microphones in front of the opening (see figure 3).

Figure 3: Typical Foley setup with tent (opened) and microphone

Impulse response

The Foley recording setups as described above rely on a number of acoustical properties of a recording and hence a recording room. These properties can be derived from an impulse response, measured inside a room with a sound source and a microphone. The impulse response describes the reaction of the loudspeaker-room-microphone system to an infinitely short pulse. It more or less looks like the recording of a handclap or gunshot, but with a much higher reproducibility and accuracy.

Figure 4 is an example of a typical impulse response. In the picture of the impulse response, the direct sound is indicated as the first peak in the green area, followed by the early reflections area in red. A strong peak in this red area is called a strong early reflection. The yellow area is called the late reverberation. If a peak occurs in this area, it is called an echo.

Measurements

Impulse responses of some typical Foley recording setups have been measured and analysed with DIRAC 4.1 software [2] in both studios. Also, the reverberation time is determined with and without curtains in both studios.

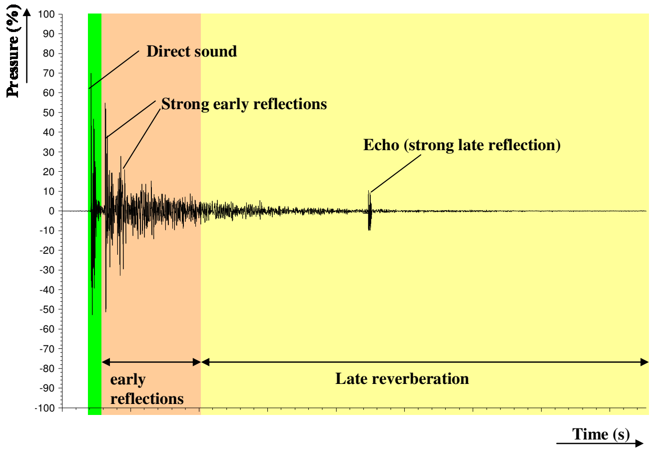

Figure 4: Typical acoustical impulse response

1) Reverberation time

Impulse responses (IR) of multiple loudspeaker-microphone (both omnidirectional) combinations have been measured with INR > 45 dB [3] to determine the reverberation time T30 for the one-third octave band frequencies from 63 Hz to 10 kHz. Figure 4 shows the reverberation time T30 for both studios with curtains open and closed. Note that for a reverberation time < 0.5 sec one cannot speak of a truly diffuse sound field and hence the parameter reverberation time may not be appropriate [4].

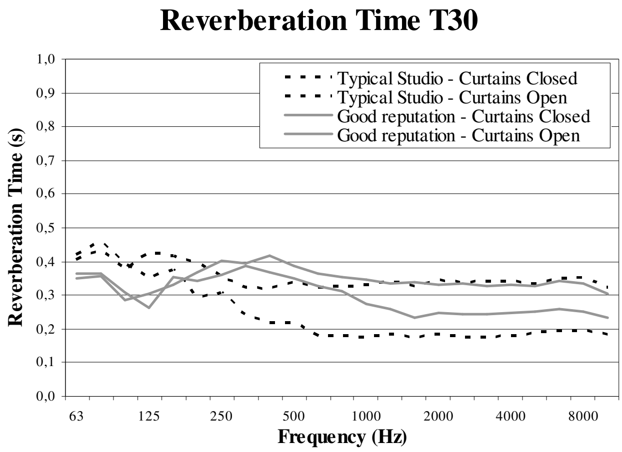

Figure 5: Reverberation time T30 versus frequency for both studios with and without curtains.

- The average T30 [5] of the typical studio is 0.33 seconds with curtains open and 0.19 seconds with curtains closed.
- The average T30 of the studio with a good reputation is 0.37 seconds with curtains open and 0.31 seconds with curtains closed.

For high frequencies above 1000 Hz, the reverberation time with curtains open is more or less equal for both studios with a reasonably flat curve, the T30 with curtains closed is lower for the typical studio, with little change at the low frequencies.

2) Direct sound versus diffuse sound

In the studio with a good reputation, IR's have been measured using a typical sound effects recording setup with two microphones as described above at sub paragraph A. The directional microphones (Neumann) that are commonly used in the studio, where also used during this measurement. As a sound source, an omnidirectional loudspeaker was used. During the measurements the curtains were opened to have a reverberation as long as possible. The objective of the recording setup is to have the direct sound 'only' in the close microphone and the diffuse sound 'only' in the corner microphone recording. In figure 6 the measured IR's of the close microphone (left) and corner microphone (right) are shown together with their Energy Time Curve (ETC is 10lg(p^2) of an IR in dB).

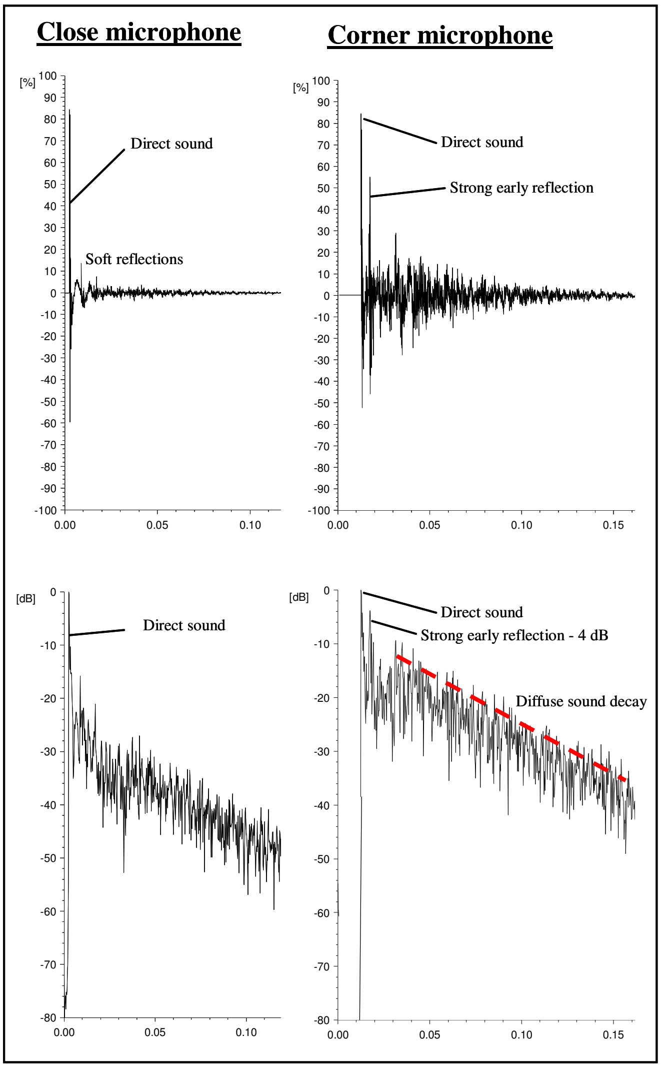

Figure 6: Impulse responses (upper graphs) and energy time curves (lower graphs) of close (left) and corner microphone (right)

- The graphs of the close microphone show that the first reflection is 15 dB lower than the direct sound. From this, it can be assumed that the direct sound will be dominant in the recording as objected.
- The graphs of the corner microphone show that the diffuse sound decay starts approximately 10 dB below the direct sound. Also there is a strong early reflection of 4 dB below the direct sound level. From this, it can be assumed that at a maximum distance from the sound source the corner microphone is still not in the diffuse sound field of the room as objected. In other words, the microphone is still within the critical distance.

3) Diffuseness of the sound field

To compare the diffuseness of the sound field the ETC of one IR measurement of both studios are presented in figure 7. Both the measurements have been performed at the same position far away, using an omnidirectional sound source and an omnidirectional microphone. The left graph shows the typical studio and the right graph shows the studio with a good reputation. During the measurements the curtains were open.

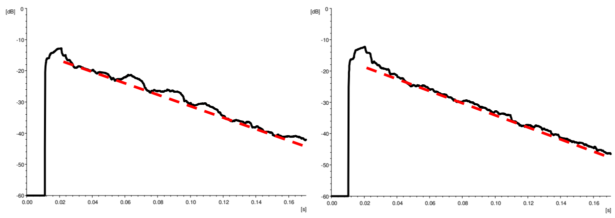

Figure 7: Energy time curves (10 ms RMS average) with trend lines in red of typical studio (left) and studio with good reputation (right).

From the graphs in figure 6 it can be seen that the sound decay of the typical studio is fluctuating more than the sound decay of the studio with a good reputation. From this, it can be assumed that the sound field of the typical studio is less diffuse than the sound field of the studio with a good reputation.

4) Introducing an early reflection

The recording technique close to a reflective wall as described above at sub paragraph B was investigated in the typical studio. This was done by measuring IR's with a directional sound source and a directional microphone close to a wall. During one IR measurement all the curtains were closed, during the other IR measurement the curtain in front of the wall close to the sound source was partly opened.

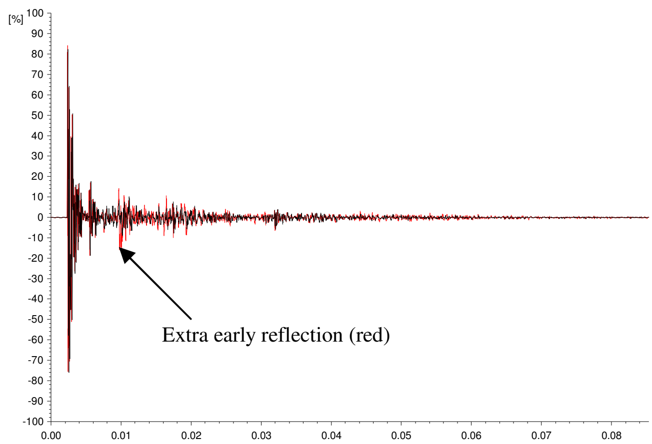

Figure 8: Overlay of two IR's close to a wall: curtains close (black) and one curtain partly opened (red)

The overlay of two IR's in figure 8 shows that indeed an early reflection is introduced by partly opening the curtain.

5) Outdoor recording situation

The outdoor recording technique as described above at sub paragraph C was investigated in the studio with a good reputation because this is the only studio of the two that has the recording tent (see figure 3). An IR was measured with a directional loudspeaker inside the closed tent (tent is still open at front and bottom) and a directional microphone. The ETC of the IR is displayed in figure 9.

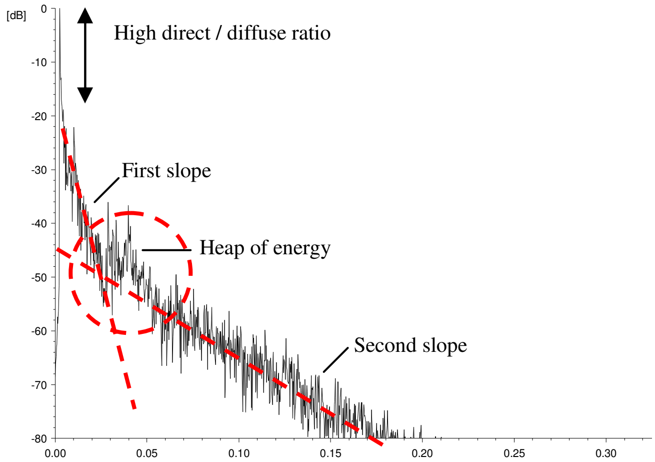

Figure 9: ETC of IR measured in front of closed tent

The ETC in figure 9 shows a high direct/diffuse ratio of at least 20 dB. Also, two different slopes are visible with a heap of energy at the crossing of the slopes. It is likely that the first slope is the reverberation of the tent and the second slope the reverberation of the studio. The tent recording setup seems to be a very specific and effective way of recording 'outdoor sound' with little reverberation inside a Foley Studio.

Conclusion

In both studios the reverberation time with curtains open is too low, resulting in a critical distance close to distance of sound source and studio boundary walls. This makes it difficult to do good diffuse sound recordings. Also, the measurements results show that the most important difference between the two Foley Studios is the difference in diffuseness of the sound field with the curtains opened. It is very likely that this is the reason that the studio with a good reputation is favored. Also, the measurements show the importance of controlling reflections inside a Foley Studio.

Recommendations

From the measurements, the following recommendations are made for the acoustics of a Foley Studio:

- Reverberation: it must be possible to change the reverberation of the room from slightly reverberant to almost dead. In the reverberant situation, it should be possible to place one microphone beyond the critical distance from the sound source. For instance, a typical critical distance for dialogue recording studios is between 0.5 m and 2 m [6]. A good way to make the room almost dead, is to make the room semi anechoic (sound absorbing walls and ceiling with reflective floor).

- The sound field should be as diffuse as possible in the slightly reverberant situation.

- Early reflections: some early reflections should be controllable for the recording engineer to play with, but without being disturbed by unwanted early reflections. The frequency spectrum of the controllable reflections should be as flat as possible.

- A sound absorbing spot in the room is needed to record outdoor sounds. An common and effective way of achieving such a spot is a sound absorbing tent.

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