Qualitative Evaluations of the Acoustics of Rooms: Real Room Studies and Headphone Studies

Martin A. Gold

Architectural Acoustics Research Group, P. O. Box 115702, Gainesville, FL 32611-5702

Abstract: This pilot study attempts to qualify the use of headphone listening to evaluate the acoustical conditions of existing and/or proposed (modeled) architectural spaces. Qualitative listening evaluations of speech and music in real rooms and via headphones were conducted by groups of college age students using a questionnaire with a seven-point bipolar rating scale. Data from real room evaluations and headphone evaluations are compared and conclusions are drawn regarding the potential for headphone listening experiments as a means to study qualitative aspects of room acoustics.

INTRODUCTION

Many new computer room modeling software packages include aurilization components that will produce either a monophonic or stereophonic impression of the acoustics of the room being modeled. It is also currently possible to make recordings in physical scale models and scale the recordings back to actual size. These simulated acoustic environments are usually played to listeners over headphones. If subtle or even global room changes will be compared in this manner it is important to begin to study the range of responses that headphone listening evaluations of acoustic environments will produce. It is proposed that if modeled carefully, headphone studies can produce an acoustically accurate illustration of a real room environment. In this pilot study, actual rooms are evaluated and compared to headphone evaluations of binaural recordings made in those rooms as a first step in the process of determining the viability of using headphone studies and to reveal the subjective responses to architectural changes in room environments.

EXPERIMENT

The overall impression of the acoustics of a room is dependant on the presence and character of primary acoustical qualities including: loudness, clarity, reverberance, spatial impression and background noise. These qualities were subjectively evaluated in multiple locations in three different listening environments: a 2000 seat multipurpose concert hall; a 600 seat lecture room; and a 120 seat lecture room. A variety of rooms was chosen to provide a range of listening environments.

Anechoic speech and music passages were used as the sound source for the evaluations. The speech signal consisted of phonetically balanced spoken passages that were digitally recorded in an anechoic environment. Two passages, *The Grandfather Passage* and *The Rainbow Passage* were played one after the other with a short pause between for the subjective evaluation of the speech signal.

Music source passages were commercially available recordings produced by the Yamaha Corporation and distributed on compact disk. There were three short string ensemble passages played in succession representing flowing and staccato movements with short pauses between them. The music passages followed the speech passages after a brief pause.

Students evaluated the passages using a 7 point bi-polar rating scale for each of the acoustic qualities indicated above. Students evaluated two positions in each of the larger rooms and only one position in the 120 seat lecture room. Students completed the subjective evaluation forms while the sources were being played in the room or while listening over headphones. Speech and music were independently evaluated.

The sound sources were played over two Kef K-12 loudspeakers. The loudspeakers were positioned adjacent to each other and aimed straight toward the rear of the room with a slight splay between them at a height of 60" (center of loudspeaker) above the floor/stage. Calibration of the source signal was done with a test tone measured at 1 meter from the source at the centerline of the room for each of the room measurements.

The students were divided into groups of 30 to 50. The groups were seated at different areas of the rooms. For example, in the 2000 seat auditorium there were listening positions at the center front main floor position; the side rear main floor position; the side front balcony position; and at a side rear balcony position. Multiple positions were also
evaluated for 800 seat lecture room. In the 120 seat lecture room, there was only a center of the room position.

The level of the test tone calibration was also measured at each of the listening locations. The recordings were played back to listeners over headphones at the same overall sound level as that measured at the actual room listening location. Students were not aware of which room they were evaluating during the headphone listening portion of the experiment. Headphone listening was done in the laboratory with 6 students per session around a table.

RESULTS

Figure 1 below compares the listener evaluation data of the speech source from the real room listening condition and the headphone listening condition for each of the rooms (Room 1: 120 seat lecture; Room 1:2000 seat auditorium; Room 3: 800 seat lecture hall). Results of the music source are similar however the there was less range in the data between rooms. If the data in comparison are within one scale point they are not considered statistically different based on preliminary 99% confidence intervals. For example, in the column for Room 3 SRM, the ratings of clarity would be considered the same for the real room and the headphone listening condition. In this case, the ratings of loudness, reverberance and spatial impression are also similar. The ratings of background noise in this case are considered different.

Reverberance and background noise were generally rated lower in the actual room evaluations than in the headphone evaluations. This may be due to the fact that the recordings had to be made in the rooms when occupied by only 2 to 3 people subsequently increasing the reverberance for the headphone listening condition. This is especially true in room 1 (120 seat lecture room). This may also have had an effect on the background noise level ratings.

Within room differences such as loudness in room two were perceived in both the actual room studies and in the headphone evaluations.

CONCLUSIONS

Preliminary studies indicate that headphone listening can give subjectively accurate indications of what will be perceived by listeners in actual rooms situations. Many of the acoustical qualities compared under actual room and headphone listening conditions were considered statistically the same. Furthermore, within room differences for some acoustic qualities were perceived in both actual room and headphone evaluations. Some differences between room and headphone evaluations may be attributable to the measurement procedure which should be revised to record the source passages in occupied rooms. Additional research should be conducted to make comparisons with a wider range of listening conditions.