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Session 2aED: Tools for Teaching Advanced Acoustics

2aED5. Using your ears: A novel way to teach acoustics
Lauren Ronsse*, Dominique J. Cheenne and Sarah Kaddatz

*Corresponding author's address: Audio Arts and Acoustics, Columbia College Chicago, 33 E. Congress Pkwy, Chicago, IL 60605, lronsse@colum.edu

Auditory simulations of physical phenomena pertaining to acoustics have been developed to enhance student learning and understanding of these conditions. The demonstrations range from simulations of fundamental concepts, such as reverberation, flutter echoes, reflections, and room modal effects, to more applied topics, such as sound transmission through barriers, mechanical system noise spectra, and varying absorption distribution in rooms. The simulations were generated by using auralization tools and processed recordings. The demonstrations may be utilized in the classroom to introduce new acoustical concepts by having students first listen to a simulation, then write and/or discuss what they hear, providing conjectures about the parameters that could create such acoustical conditions. The goal of the demonstrations is to encourage students to use their ears as part of a quantitative and qualitative assessment of acoustical phenomena.

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INTRODUCTION

The Audio Arts and Acoustics Department at Columbia College Chicago (CCC) offers a Bachelor of Science in Acoustics degree. Courses in the Acoustics Program span a wide range of areas, including psychoacoustics and perception, architectural acoustics, noise and vibration control, and environmental acoustics. Faculty members in the Acoustics Program have found that auditory demonstrations that reinforce concepts presented in the classroom are a useful tool to enhance student learning. Audio files are widely accessible to demonstrate psychoacoustics phenomena (Houtsma et al., 1989). However, though some audio files pertaining to room reverberation are available (Russell, 2011), further development of auditory demonstrations pertaining to architectural acoustics, environmental acoustics, and noise control phenomena is needed. The goal of this project is to develop an extensive set of auditory simulations to fulfill this need. When used as teaching tools in the classroom, these simulations will enable students to use their ears to perform both quantitative and qualitative assessments of the acoustical concepts presented.

AUDITORY SIMULATIONS

Auditory simulations have been generated making use of the acoustics laboratory facilities, measurement equipment, and auralization tools at Columbia College Chicago. The reverberation chamber and G.R.A.S. Sound & Vibration KEMAR manikin utilized for portions of this project are shown in Figure 1. The semi-anechoic chamber utilized for some of the recordings is shown in Figure 2.

![Reverberation chamber and KEMAR at Columbia College Chicago.](image1)

**Figure 1.** Reverberation chamber and KEMAR at Columbia College Chicago.

![Semi-anechoic chamber at Columbia College Chicago.](image2)

**Figure 2.** Semi-anechoic chamber at Columbia College Chicago.

**Architectural Acoustics Simulations**

Architectural acoustics simulations encompassing reverberation, reflections, flutter echo, liveness, room modes, and absorption topics have been generated. Varying degrees of reverberation experienced in spaces with different volumes and in different locations (center, near one wall, near two walls, and near a corner) were auralized using computer modeling software. Binaural recordings of flutter echo with hand claps under three conditions of palm
positioning (low, medium, and high) were made. The perceptibility of reflections at various delay times (20 ms, 40 ms, 80 ms, and 100 ms) without reverberation has also been simulated. The differing levels of liveliness perceived due to a variety of surface treatments (absorptive, diffusive, and specularly reflective) were binaurally recorded. Room modes present in the highly modal reverberation chamber (shown in Figure 1) were binaurally recorded during walk-throughs of the space. The effects of differing absorption distributions were auralized by positioning the entire room absorption either on the ceiling, sidewall, or front wall in two spaces with differently-sized volumes. These architectural acoustics simulations will be utilized as teaching tools in both the Architectural Acoustics and Acoustics of Performance Spaces courses at CCC.

Environmental Acoustics Simulations

Simulations of road traffic were generated to compare the perception of traffic noise using point source acquisition versus line source acquisition. Three different distances from the traffic noise source were recorded for both a moving point and free flowing traffic patterns. These environmental acoustics simulations will be used to demonstrate the differences perceived between the two different data acquisition methods in the Environmental Acoustics course at CCC.

Noise Control Simulations

Auditory demonstrations of mechanical noise spectra and transmission loss have been generated. The mechanical noise was simulated by spectrally shaping noise to attain spectra with unbalanced amounts of mid, low, and high frequency noise in comparison to a balanced spectrum. Examples of noise with the following Noise Criteria (NC) and Room Criteria (RC) Mark II spectra as defined by ASHRAE (ASHRAE, 1999) were included: NC-40, RC-40(N), RC-40(LF), RC-40(MF), and RC-40(HF). Simulations of airborne sound transmission loss were created for different construction samples, including drywall alone, drywall with insulation added, typical glass, high-performance glass, and concrete. By utilizing a variety of construction types, a wide range of coincidence dip effects and overall sound transmission loss may be heard. These noise control simulations may be utilized in both the Engineered Acoustics and Architectural Acoustics courses at CCC.

CONCLUSION

The outcomes of this project provide a wide range of auditory simulations to demonstrate architectural acoustics, environmental acoustics, and noise control concepts. Because these simulations cover both fundamental and applied concepts, they provide valuable teaching tools for acoustics courses at varying levels of education. An effective use of these simulations would be to have the students first listen to a simulation before presenting a new concept, then have the students write and/or discuss what they hear. This would encourage students to employ listening and critical thinking skills in the classroom, while providing them with skills to recognize common acoustical phenomena while practicing acoustics in the field.

REFERENCES