MEASUREMENT OF TYPICAL SPEECH AND BACKGROUND-NOISE LEVELS IN UNIVERSITY CLASSROOMS DURING LECTURES

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Introduction

As part of a study on classroom acoustics [1], an experimental procedure has been developed for determining typical long-term speech and background-noise levels in university classrooms during lectures. A particular objective was to determine typical levels of student-activity noise as separate from ventilation noise; previous work had suggested that it can be surprisingly high [1]. The procedure involved recording lectures, digitizing and filtering the recordings, and determining long-term sound-pressure-level distributions. The procedure has been applied to lectures in UBC classrooms.

Classroom Recordings

A total of 18 lectures were recorded at up to four positions in 14 classrooms. The classrooms were seminar and lecture rooms which contained 10-291 seats and 7-290 students, and with unoccupied mid-frequency reverberation times that varied from 0.5-1.8 s. Both male and female instructors - teaching a wide variety of subjects at various academic levels - were involved. Recordings were made using calibrated Bruel & Kjaer 4145 microphones and a TASCAM DA30 Mk II digital tape recorder. Data were collected for 10-15 min - in three blocks at the beginning, middle and end of the class - at each position. As a cross check, ventilation-noise levels were measured at each test position in each classroom on a separate occasion using a sound-level meter.

Analysis Procedure

Recordings at each position in each class were digitized and filtered using digital 63-8000 Hz octave-band and A-weighting filters. Software processed the resulting pressure time histories as follows: the signals were squared; short-term (using intervals which decreased over the test frequency range from about 160 to about 1 ms) mean square pressures were calculated; interval sound-pressure levels were calculated; sound-pressure-level frequency distributions were determined and plotted; the resulting distributions were best-fit by one, two or three normal-distribution curves in an attempt to identify peaks. Only the A-weighted results have been analyzed to date, and will be discussed here.

Results

Attempts to best-fit one or two normal-distribution curves to the results generally gave a poor fit; however, three curves usually gave a very good fit. These were identified with three components of classroom sound - speech signal, ventilation noise and student-activity noise. However, in most cases it was not immediately obvious which, if any, of the three best-fit levels corresponded to which sound component - nor what was the correct level order.

In order to cast some light on this, levels were compared with cross check, ventilation-noise levels were measured at each test beginning, middle and end of the class - at each position. As a microphones and a TASCAM DA30 Mk II digital tape recorder. Analysis Procedure results have been analyzed to date, and will be discussed here. Results generally gave a poor fit; however, three curves usually followed: the signals were squared; short-term (using intervals which decreased over the test frequency range from about 160 to about 1 ms) mean-square pressures were calculated; interval sound-pressure levels were calculated; sound-pressure-level frequency distributions were determined and plotted; the resulting distributions were best-fit by one, two or three normal-distribution curves in an attempt to identify peaks. Only the A-weighted results have been analyzed to date, and will be discussed here.

Summary of the results:

Background noise - Ventilation-system noise levels varied from 33-46 dBA. Student-activity noise levels varied from 38-49 dBA. Total background-noise levels varied from 39-50 dBA.

Speech level - Speech levels at individual positions varied from 41-60 dBA. Room-averaged levels varied from 47-57 dBA with an average value of 53 dBA. Differences between male/female speakers and front/back seat positions altered levels by ±1.2 and ±1.5 dBA, respectively. Speech levels did not vary significantly with room acoustical conditions. It can be hypothesized that instructors adjust their voice levels to compensate for the acoustical conditions and maintain a constant speech level. To test this, speech levels and diffuse-field theory were used to estimate long-term instructor sound-power levels. These varied from 56-68 dBA with male/female differences varying this value by ±1.2 dBA, respectively. There was a strong correlation with room size - average speech power levels of 61 dBA (<30 seats), 62.5 dBA (30-80 seats), 64 dBA (>80 seats) - supporting the hypothesis.

Signal-to-noise ratio - It is speech-signal to total-background-noise ratio which determines speech intelligibility. Thus, for each position in each classroom ventilation- and student-activity-noise levels were added energetically and the results subtracted from the speech level. The resulting individual-position signal-to-noise ratios varied from 2-13 dBA. This was in all cases lower than the signal-to-noise ratio of about 15 dBA considered necessary for excellent speech intelligibility for normal-hearing adults [3].