Predicting combined effect of reverberation and noise on binaural speech recognition in real classroom acoustics

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Background, Good acoustics in classrooms is necessary to guarantee appropriate communication, teaching and learning practices. This work focuses on investigating the influence of reverberation and noise in real classrooms on binaural speech recognition.
Material and Methods, Five experiments were designed based on realistic receiver positions in two representative Italian classrooms, one with an acoustical treatment and one without, where room impulse responses were measured at the ears of a head and torso simulator. In each room, interfering noise sources were placed at different distances and azimuths with respect to the receivers to account for binaural cues in speech recognition, namely at 0°, 120° and 180°. Babble noise was recorded in real classrooms during a break between lessons. The respective impulse responses were convolved with speech signals of the simplified Italian matrix test. This was presented via headphone to a group of adult normal-hearing listeners. Speech recognition was measured adaptively converging to a signal-to-noise ratio yielding 80% correct recognition scores (SRT80). For the classroom with a poor acoustics, several solutions for treatment were simulated using CATT-Acoustics®, including the adjustment of the absorption and scattering coefficients of surfaces to reach an optimum reverberation time. The effectiveness of these acoustic treatments was also evaluated in terms of speech recognition enhancement using the Binaural Speech Intelligibility Model (Rennies et al., 2013)
Results, In all conditions, lower (better) SRT80s were measured for good room acoustics, confirming the detrimental effect of reverberation on speech recognition. A major effect of the reflections was also evident in the increase in SRT80s when the distance between speech source and listener increased. The binaural unmasking was observed only for a short distance between speaker and listener in a room with a short reverberation time. Model predictions for untreated rooms were in line with the measured SRT80s. Model predictions indicated an improvement in SRT80 after acoustical treatment intervention.
Conclusion, The binaural speech intelligibility model accounts for an influence of reverberation and noise on speech recognition. It should become a supporting tool for the assessment of speech recognition in real rooms and for assessing the effectiveness of the acoustical treatment.