SPMSOFT AND SPEECH PRIVACY MEASUREMENT IN OPEN-PLAN OFFICES

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Introduction

A successful open-plan office design requires '*acceptable*' or '*normal*' privacy corresponding to AI $\leq$ 0.15 and an ambient noise level of close to 45 dBA[1-3]. This can only be achieved by careful attention to all important design details. If any key design parameters are ignored, AI $\leq$ 0.15 will not be reached, and the office will not be a success. To ensure that changes systematically improve speech privacy, it is helpful to have in situ objective measurements to give unbiased assessments of conditions. Although this has been difficult to do using conventional measurements, the new SPMSoft program makes possible convenient in situ assessments.

New Speech Privacy Measurement Software

SPMSoft is new measurement software intended to measure privacy in open-plan offices during occupied conditions without unduly disturbing the occupants. Sound attenuations between locations in an office are determined from impulse response measurements. Daytime ambient noise levels can also be measured and speech privacy measures calculated in situ at each measurement location. SPMSoft calculates values of the Articulation Index (AI)[4], the Speech Intelligibility Index (SII)[5], the Speech Transmission Index (STI)[6] and an A-weighted signal-to-noise ratio (SNR(A)). The user sees immediately how close the measured conditions are to the goals of AI $\leq$ 0.15 and an ambient noise level of 45 dBA.

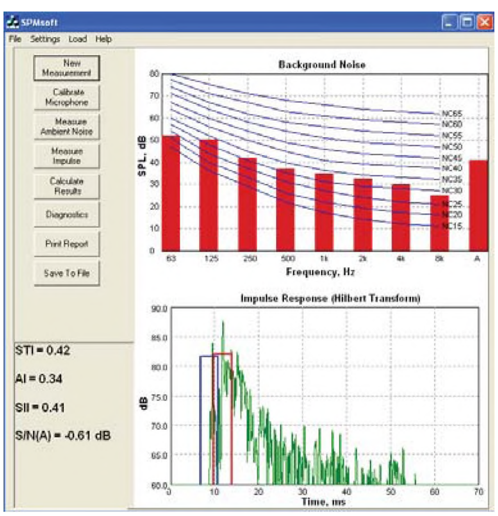

Fig. 1 SPMSöft main screen: measured ambient noise spectrum (upper) and impulse response envelope with the blue and red boxes identifying the initial diffracted path sound and the initial ceiling reflection sound (lower).

The program displays the envelope of the measured impulse response and the spectrum of the measured ambient noise as illustrated in Fig. 1. These displays give the user the key information required to diagnose the cause of acoustical problems. The two most important paths are usually the initial ceiling reflection and the initial screen diffracted path (whereby speech sound diffracts over the separating partial height panel). After the user enters some dimensions, the program indicates the components of the impulse response that are due to the sound arriving by the initial ceiling reflection path and via the initial panel diffraction path (red and blue boxes respectively in the lower graph on Fig. 1). The relative heights of these two components of the impulse response relate to the relative importance of increasing either the panel height or the ceiling absorption for improving speech privacy of the measured condition.

An ambient noise level of close to 45 dBA is an optimum compromise between being too loud and disturbing and too quiet and not masking unwanted speech sounds[1-3]. It is typical of ventilation system noise levels found in many offices. Privacy measures can be recalculated with a more ideal ambient noise spectrum, than that measured, to explore the importance of changes to ambient noise levels. From the impulse response display and ambient noise level effects, the user gets an immediate indication of the relative importance of improvements to the key parameters: panel height, ceiling absorption and ambient noise levels, for improving speech privacy.

Software Operation

Fig. 2 illustrates a typical measurement setup and a block diagram of the external hardware required. A portable computer is connected to an external sound card. The program outputs sine-sweep test signals via the sound card and power amplifier to a small loudspeaker located in one workstation. A microphone is typically located in the adjacent workstation and connected to the computer via the external sound card.

The user simply proceeds, from top to bottom, through the 8 measurement buttons shown in Fig. 1. New measurement information is entered using the first button and the microphone is calibrated using the second button. The third button starts the measurement of ambient noise levels for a user-specified duration. The results are stored as 1/3-octave band levels but displayed on the upper part of the main screen as octave band levels.

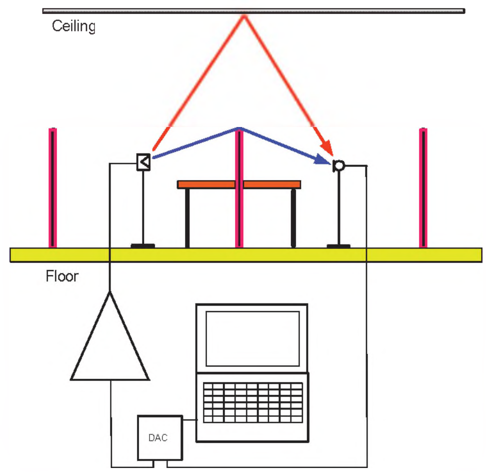

Fig. 2. Typical measurement setup showing a section through a pair of adjacent workstations.

The fourth button starts the impulse response measurement, which is displayed as the impulse response envelope in the lower part of the main screen in Fig 1. By using up to 99 repeats and synchronously averaging the responses, good results can be obtained without disturbing the occupants. Pressing the fifth button calculates the speech privacy indices AI, SII, STI and SNR(A).

The user can enter the dimensions of the office by using the 6th button to allow the program to determine the expected arrival times of the initial ceiling reflection (red box, Fig. 1) and the screen diffraction pulse (blue box, Fig. 1). The last 2 buttons make possible printing of results and saving them to files. The relative importance of the identified two sound paths (red and blue boxes on Fig. 1) and the measured ambient noise levels give the user immediate feedback as to the most critical factors for improving speech privacy.

Measurement Examples

SPMSoft is available for download[7] along with a users manual[8] and reports describing its use[9] as well as the results of open-plan office case studies using SPMSoft[10]. Systematic measurements in real offices have demonstrated the effects of: ceiling absorption, panel height, window reflections, furniture placement, ambient noise levels and excessive reflected sound [9,10]. Because of the speed of measurements, more detailed studies are possible such as calculating contours of speech privacy within workstations [11]

The measurement studies demonstrated that more absorptive ceilings can decrease AI values by 0.1 to 0.2 and increase the area around the source within which acceptable privacy is achieved by a factor of 8. Higher workstation panels were shown to decrease AI values by as much as 0.15.

Sound reflections from adjacent windows were shown to increase AI values by 0.1 compared to other workstations without window reflections. The reflections from windows could be identified on the measured impulse response envelopes.

Surprisingly the furniture arrangements in workstations were also found to systematically effect privacy. Where there were tables or desks near the centre of the workstations, AI values were increased by 0.1 to 0.15 due to the added reflection energy from these flat horizontal surfaces.

Conclusions

The new SPMSoft program makes it possible to systematically identify and solve acoustical problems in open-plan offices and to better improve acoustical conditions in the offices. This complements existing acoustical design software for open-plan offices[12].

Acknowledgement

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