DIRECTIVITY OF HUMAN TALKERS

A.C.C. Warnock[1], W.T. Chu[1] and J-C. Guy[2]
[1]Institute for Research in Construction, National Research Council Canada, 1200 Montreal Road, Ottawa, K1A 0R6,
alf.warnock@nrc.ca
[2]Student, INSA de Lyon, France

1. INTRODUCTION

Human talkers radiate more speech energy forward than to the side or to the rear. This directivity can be utilized when planning open office layouts to increase speech privacy. While talker directivity had been studied[1,2,3] not enough information had been published to allow detailed computer calculations. So, as part of a project studying new kinds of open-offices, the sound fields around 20 male and 20 female talkers were more completely examined.

2. DATA COLLECTION

The sound field surrounding the talkers was surveyed using two arrays of microphones arranged on two fixed arcs on orthogonal meridian planes of a sphere of 1-meter radius centered at the talker's mouth in the anechoic chamber at IRC. Figure 1 shows a schematic drawing of the arrangement of the 16 microphones used in the measurement.

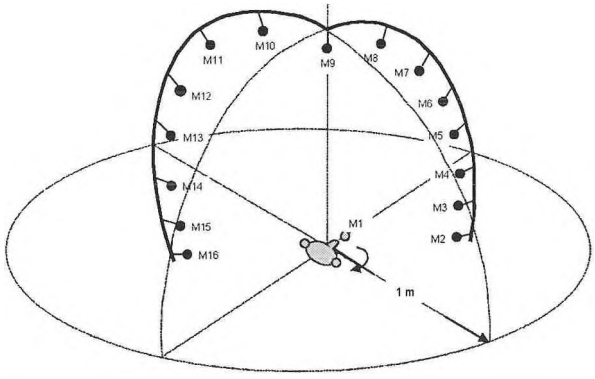

Figure 1: Schematic drawing of the microphone arrangement used for the survey of the sound field surrounding human talkers.

The subject sat on a rotatable chair. The height was adjusted so the subject's mouth was located at the center of the spherical surface of the microphone arrays with the subject looking straight ahead. For a complete directivity measurement, the subject was rotated through 90° at 15° intervals. Since there were two microphone arcs, this covered an azimuthal range of 180° on one side; symmetry about the head was assumed. Microphone M9, directly above the talker's head, was used as the reference.

The talker was asked to remain seated with the same posture and to talk normally at each orientation on some subject for 40 seconds without being concerned about exact duplication of the words. Signals from the microphones were recorded simultaneously on two synchronized DAT recorders (Tascam DA-38). The recorded signals were analyzed in 1/3-octave bands using a B&K 2144 real time analyzer programmed to collect 30-second L_{eq} values. When analysis was complete, relative levels were obtained for 141 positions distributed on a sphere around the talker's head.

As well as obtaining directivity matrices, some other factors were investigated. The main conclusions are listed here.

- The average male voice spectrum shape obtained in these measurements agreed well with that from field measurements[4]. Some differences were observed for the female voice spectra.
- No significant differences in directivity were detected between male and female talkers although average spectra differed.
- No significant differences in directivity were detected between English and French talkers. The frequency content of the two languages was similar.
- Similar directivities were obtained for both normal and loud voice levels but significant changes behind the talker were observed for low voice level.
- One-third-octave band directivities showed fairly good agreement with those published by Moreno & Pfretzschner[2] and by Dunn & Farnsworth[1].
- Similar directivities were obtained for the average human talker and the B&K Head and Torso Simulator.

The directivity patterns for the males, females and all subjects are shown in Figure 2 for the vertical and the horizontal planes. The figure shows that there is a reduction of around 7 dBA in voice level directly behind a talker. By positioning work stations to take advantage of this directionality, intrusive speech can be reduced in open-office workstations provided the furnishings are sufficiently absorptive. The detailed directivity information can be used in computer models of proposed office arrangements.

3. VOCAL EFFORT

Only one male speaker was asked to vary the loudness of speech so general conclusions can not be made. However, the plots in Figure 3 show that in this case, the speech energy directed behind the subject was about 4 dBA

less than when a normal or raised voice effort was used. Thus inducing office occupants to lower their voices may have even more benefits when occupants face away from each other.

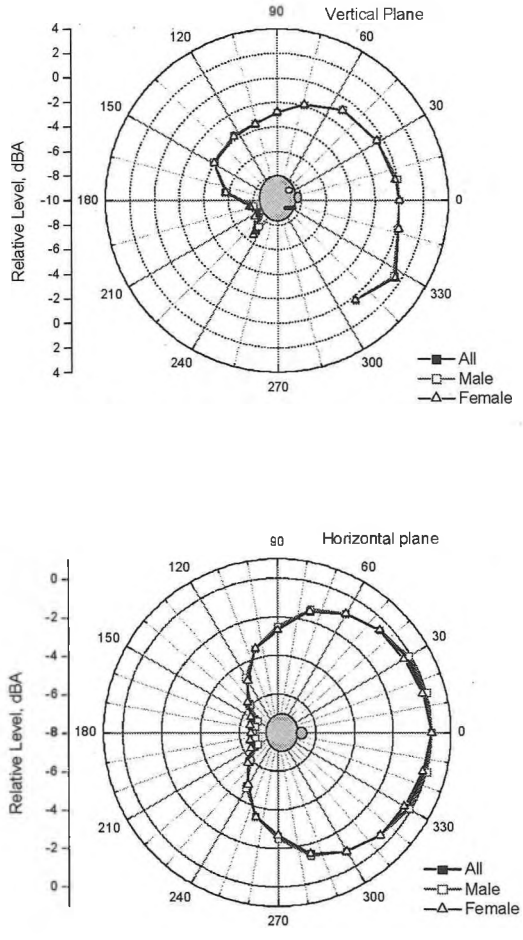

Figure 2: Comparison of the relative A-weighted levels in the frontal vertical and horizontal planes of the male and female talkers.

4. SUMMARY

The details of the work are available in an IRC internal report[5].

ACKNOWLEDGEMENTS

This work was supported by Public Works and Government Services Canada.

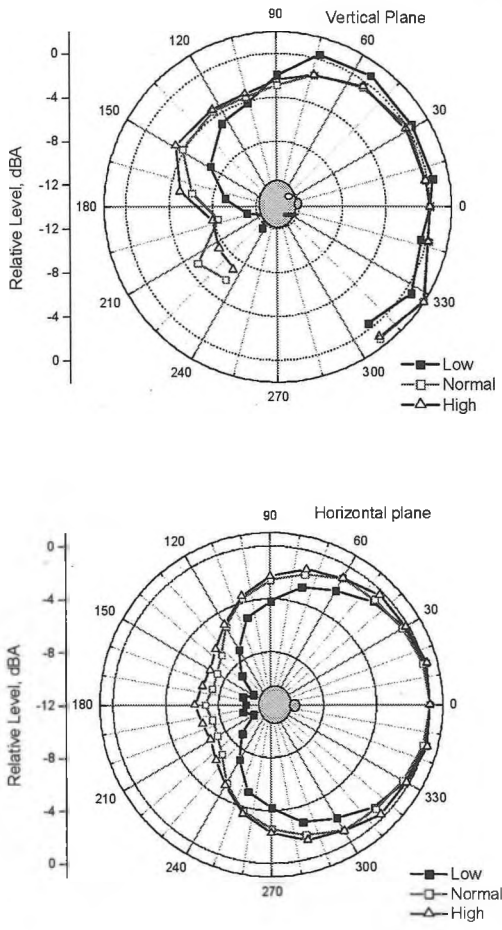

Figure 3: Directivity patterns of the relative A-weighted levels of a male talker speaking at three different voice levels.

REFERENCES

[1] Dunn, H.K. and Farnsworth, D.W. "*Exploration of Pressure Field Around the Human Head During Speech*", J.A.S.A. Vol. 10, pp184-199, January 1939.

[2] Moreno, A. and Pfretzschner, J. "*Human Head Directivity in Speech Emission: A New Approach*", Acoustics Letters Vol. 1, pp78-84, 1978.

[3] McKendree, F.S. "*Directivity Indices of Human Talkers in English Speech*", Proceedings Inter-Noise 86, pp911-916, July, 1986.

[4] Warnock, A.C.C. and Chu, W.T. "*Voice and Background Noise Levels Measured in Open Offices*," Internal Report IR-837, January 2002.

[5] Chu, W.T and Warnock, A.C.C. "Detailed Directivity of Sound Fields around Human Talkers." IRC Research Report 104, 2002.