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Polar frequency response of the human ear

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Humans can localize sounds in azimuth and elevation without head movement, and even to some extent monaurally Interaural time and intensity difference cues are insufficient for this degree of auditory localization (Mills, 1972) Experiments are being performed to determine what additional information which could be used in auditory localization is available in man.

The polar frequency response of the human ear was determined with a small microphone ($2{\cdot}5 \times 6 \times 7$ mm, Knowles, BL or BT series) in the auditory canal to record sound pressure changes close to the tympanic membrane. Broad-band noise was used as a sound source in a space in which reflexions were minimized (in an open area) Angles of azimuth and elevation were varied systematically by alterations of the angle of the listener's head relative to a single sound source. Frequency response curves relative to the intensity at the same position in space without the head in position were plotted from measurements of sound pressure at different frequencies using a frequency spectrum analyser (Tektronix 1L5, bandwidth usually set to 500 Hz).

One result is that for high frequencies e.g. 3–6 kHz) sounds from azimuth 30° are more intense than from 150° (mean = +8·4, *vs.* 1·3 dB, $P < 0{\cdot}01$, Wilcoxon test). Similarly, for 60° *vs.* 120° the relative intensities are +10·1 *vs.* 5·5 dB, $P < 0{\cdot}01$, and for 0° *vs.* 180° +5·6 *vs.* −2·2 dB, $P < 0{\cdot}01$ In contrast, at low frequencies (e.g. 0·2 − 1 kHz) the average differences for the pairs of angles given above was 0·3 dB. Thus information which could be used to distinguish, for example, between front and back is present in the frequency response of the human ear

Experiments with transient stimuli 0·2 msec clicks) also show that information about the position of a sound source in space is contained in the sound pressure changes recorded in or near the auditory canal.

This method, of recording sound pressure changes within the external auditory canal, allows information which could contribute to auditory localization to be analysed. With the method it can also be shown that the sounds recorded in the external auditory canal do contain sufficient information for three-dimensional auditory localization.

REFERENCE

Mills, A. W (1972). In *Foundations of Modern Auditory Theory*, vol. 2, ed. Tobias, J V New York: Academic Press.