

Some Measurements of Interaural Time Difference Thresholds

R. G. KLUMPF AND H. R. EADY
U. S. Navy Electronics Laboratory, San Diego 52, California

(Received August 8, 1955)

Thresholds for the detection of interaural time difference were determined by ten listeners (1) for band-limited random noise (150–1700 cps), (2) for a 1000-cps tone, and (3) for a 1-millisecond click. The average interaural time differences corresponding to 75% correct detection in the symmetrical two-alternative tests were (1) 9 microseconds, (2) 11 microseconds, and (3) 28 microseconds. Ranges of individual thresholds and group psychometric functions are presented.

IN 1953 preliminary measurements were made of the interaural time difference threshold of a group of listeners for a variety of sounds. A larger program of measurements, then planned, was never carried out. Since the results of the preliminary measurements may be of interest to others, they are presented here in abbreviated form.

A two-channel circuit containing electrical delay lines and terminating in earphones was used to control, independently, the time and intensity relationships of signals delivered to the ears of a listener. In one channel the signal could be delayed from 0 to 1000 microseconds in 1-microsecond steps and in the other channel from 0 to 900 microseconds in 18-microsecond steps.

In the method used, the listener heard a pair of sounds, a standard and a variable, and judged which was further to the left. The standard was presented with zero interchannel time difference and the variable with an interchannel time difference leading in the left ear. The order of presentation of the two sounds comprising a pair was randomized. Each signal was at maximum intensity for approximately 1.4 seconds and was turned on and off over 0.3 second. A 2-second interval of silence separated the two. Interchannel intensity difference was zero for both sounds, hence the only clue upon which the listener could base his discrimination was interchannel time difference.

Results for three of the sounds tested are shown in Fig. 1. The solid dots represent results obtained with a band of noise generated by passing random noise through a half-octave filter set to 150–1700 cps band pass. The crosses are data obtained with a 1000-cps tone. The circles are for a click of 1-millisecond duration.

The interaural time difference threshold (75% correct point) of ten listeners for the noise band is 9 microseconds. Individual thresholds ranged from 5 to 18 microseconds. For the 1000 cps tone, the group threshold is 11 microseconds with a range from 7 to 23 microseconds. For the click, the group threshold is 28 microseconds with a range from 19 to 46 microseconds.

Table I lists interaural time difference thresholds for other signals along with the number of listeners and the number of judgments for each of the five points determining the threshold curve.

TABLE I. Interaural time difference thresholds in microseconds for various signals as read from curves like those shown in Fig. 1.

Signal	Threshold in microseconds	Number of listeners	Judgments per point per listener
Noise	Broad band ^a	10	160
	150–1700 cps ^b	9	80
	425–600 cps ^b	14	160
	410–440 cps ^b	19	80
	2400–3400 cps ^b	44	80
	3056–3344 cps ^b	62	80
Clicks (1 millisecond duration)	Single	28	10
	Repeated, 30 clicks in a 2 second burst	11	13
Tones	90 cps	75	10
	125 cps	56	9
	250 cps	27	9
	500 cps	17	9
	1000 cps	11	9
	1300 cps	24	10
	1500 cps	...	10
	1800 cps	...	10
	3200 cps	...	10

^a Random noise limited by the frequency response of the PDR-8 earphones used.

^b Half-power points.

Thresholds for noise signals appear to be much the same as thresholds for pure tones within the same pass band as the noise. Thus, the threshold of 14 microseconds for a 425–600 cps noise band is the same as the estimated threshold for a 600-cps tone and the threshold

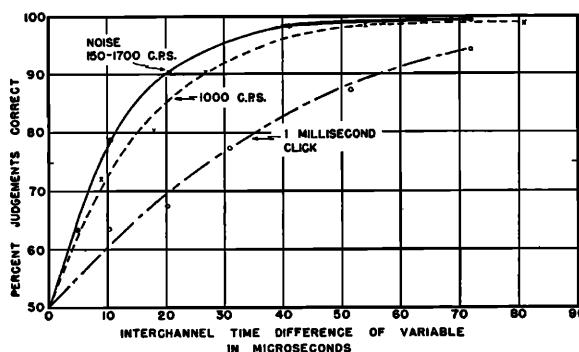


FIG. 1. The percent judgments correct as a function of the interchannel time difference of the variable sound. The number of judgments per point per listener and the number of listeners used are listed in Table I.

of 19 microseconds for a 410–440 cps noise band is the same as the estimated threshold for a 440-cps tone. This relationship would not apply for frequencies above about 1300 cps since listeners were unable to detect changes in interchannel time difference for tones of 1500, 1800, and 3200 cps. However, the threshold of 62 microseconds for the 3056–3344 cps noise band which had no audible components below 2000 cps suggests that sensitivity to time difference is not restricted to low frequencies when the signal is a noise.

The measurements listed in Table I were made with the standard at zero interchannel time difference. As

shown in Fig. 1, the threshold for a 150–1700 cps noise band under this condition is 9 microseconds. When the standard has an interchannel time difference of 430 microseconds leading in the right ear, the threshold is 29 microseconds. With the standard at 790 microseconds, the threshold is 50 microseconds. Thus, the threshold for this noise band increases by about 1 microsecond for every 20 microseconds of displacement of the standard.

All of the listeners used had normal hearing in both ears. Pure tones were presented at 65 db and noise signals at from 60 to 80 db over-all re 0.0002 dyne/cm².

Just Noticeable Differences in Dichotic Phase*

J. ZWISLOCKI AND R. S. FELDMAN†

Psycho-Acoustic Laboratory, Harvard University, Cambridge, Massachusetts

(Received February 3, 1956)

The just noticeable difference in dichotic phase, as a function of sensation level and of frequency, has been determined on a number of listeners with normal hearing. The test tones were transmitted by earphones, and the phase difference between the ears was varied by means of an electronic phase shifter. The psychophysical method used combined paired comparisons and forced choice. The first tone pulse of each pair presented was kept at a constant phase difference at which the subject localized the sound source as equidistant from his ears. The dichotic phase difference of the second pulse was varied irregularly ("randomly"). The results show that the sensitivity to dichotic phase difference is highest (2° of phase) at medium sensation levels, and that the jnd increases with positive acceleration as the sound frequency increases. Around 1300 cps the jnd becomes so great that it cannot be measured. The dichotic time difference calculated from the measured jnd in phase has a minimum near 800 cps.

THE psychophysical literature contains a number of descriptions of the measures of just noticeable differences. In audition alone, measures of jnd have been made on all three basic attributes of acoustic vibration—intensity, frequency, and phase.

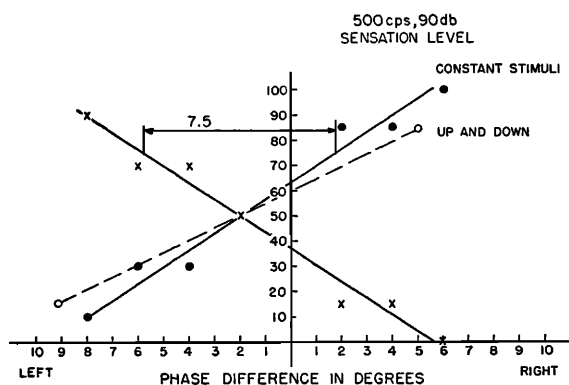


FIG. 1. Cumulative distribution curves. Closed circles indicate the percentage of tone pulses judged to be to the right of the standard pulse; the crosses indicate the percentage of pulses judged to be to the left. The open circles joined by a dashed line correspond to values calculated from the up-and-down method.

* This work was carried out under Contract N5ori-76 between Harvard University and the Office of Naval Research, U. S. Navy (Project NR142-201, Report PNR-182). Reproduction for any purpose of the U. S. Government is permitted.

† On leave from the University of Massachusetts.

Almost every psychophysical experiment, however, has led to a different value for the attribute measured, with the result that the reader of the literature is offered a wide choice of jnds for any given attribute. The jnd seems to be particularly dependent on the psychophysical method used. This dependency is emphasized in papers by W. A. Rosenblith and K. N. Stevens¹ and by Pollack.² Rosenblith and Stevens mention four classes of jnd for frequency, the AX, the ABX, the quantal, and the modulation jnd. For the jnd in intensity Pollack has found a "floating standard," "single standard," "single comparison standard," "roving standard," and "roving comparison standard" jnd.

No classification has been found for the jnd in phase because of the paucity of reference. And, of the few scattered references in the literature, the majority do not concern pure phase, but are expressed as time differences.

The experiments described herein must be considered as preliminary rather than final. We did not try to make our measurements very precise, in the expectation that they would not represent the last word in any case, and

¹ W. A. Rosenblith and K. N. Stevens, *J. Acoust. Soc. Am.* **25**, 980 (1953).

² I. Pollack, *J. Acoust. Soc. Am.* **26**, 1056 (1954).