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Letters to the Editor

REMARK ABOUT THE ANALYTIC EXPRESSION OF THE TONE-PITCH THRESHOLD AS A FUNCTION OF FREQUENCY

ЗАМЕЧЕНИЕ ОБ АНАЛИТИЧЕСКОМ ВЫРАЖЕНИИ ДЛЯ ПОРОГА ВЫСОТЫ ТОНА КАК ФУНКЦИИ ЧАСТОТЫ

PETER BALÁŽ,* Trnava

In order to describe quantitatively the auditory system, it is necessary to determine the mathematical relations between the physical stimuli and the corresponding sensory acoustical characteristics. One of such characteristics is the tone-pitch duration threshold, defined as the minimal duration of the tone pulses necessary for its perception as a sound with a tonal character. Several authors have measured the frequency dependence of the duration threshold for the tone-pitch [1—3]. The average values of the threshold for the tone-pitch $\bar{t}_T$ as a function of the frequency are plotted in Fig. 1. They can be expressed by the analytical formulas

$$\bar{t}_T = 9.5/[1 - \exp(-f/f_0)] \qquad (1)$$

within the range of 100 Hz to 4000 Hz, and

$$\bar{t}_T = 10^2/(12.1 - 4.21 \times 10^{-4} f)$$

within the range of 4000 Hz to 10 000 Hz, where f represents the frequency of the non-stationary tone pulses and $f_0 = 300$ Hz [4]. Equations (1) are arranged so that $\bar{t}_T$ is obtained in msec if the frequency is given in Hz.

In Fig. 2 there are plotted the mean measured values for $\bar{t}_T$ in dependence on the frequency within the range of 100 Hz to 1000 Hz, whence it is evident that the function $\bar{t}_T(f)$ in this frequency range is well approximated by the equation

$$\bar{t}_T(f) = \frac{2700}{f} + 6.8. \qquad (2)$$

Within the interval of 1000 Hz to 4000 Hz the function $t_T(f)$ has practically the constant value of $\bar{t}_T(f) = 9.5$ msec.

The average values $\bar{t}_T$ plotted in Fig. 1 have been measured with a random initial phase of the non-stationary tone pulses. Recent works concerning the determination of the tone-pitch duration threshold, however, indicate that the initial phase parameter affects the tone-pitch duration threshold. Within the interval of 125 Hz to 1000 Hz the tone-pitch duration threshold increases with the increase of the initial phase [5, 6].

* Katedra fyziky Pedagogickej fakulty UK, 917 24 TRNAVA, Czechoslovakia.

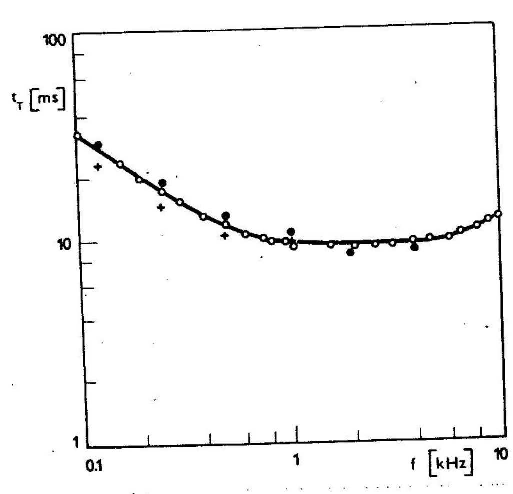

Fig. 1. Frequency dependence of the mean values of the duration threshold for the tone-pitch (after [4]). The values of the duration threshold for the tone-pitch measured at the initial phase of 0° and 80° are marked by crosses and by dots, respectively.

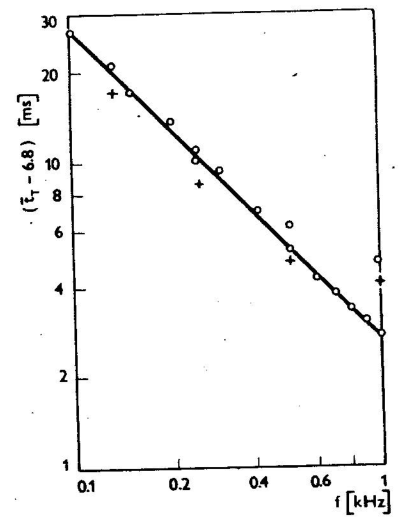

Fig. 2. Dependence of $(\bar{t}_T - 6.8)$ on frequency. The values of the duration threshold for the tone-pitch measured at the initial phase of 0° and 80° are marked by crosses, or by dots, respectively (after [6]).

The question arises: what is the relation between the values of $\bar{t}_T$ measured at an exactly defined initial phase angle [6] and the mean values $\bar{t}_T$, determined at a random initial phase and being in agreement with equation (2), or in other words, how to change equation (2) so that it fits well the values t_T with the defined initial phase.

When comparing the mean values of $\bar{t}_T$ at the initial phase of 0°, resp. 80° (at the constant intensity level 80 dB) [6], we can see that $\bar{t}_T$ at the frequency of 125 Hz is in agreement with t_T at the initial phase of 80°. The value of t_T at the initial phase of 0° is shorter than $\bar{t}_T$. For the frequencies of 250 Hz and 500 Hz there holds

$$t_{T,0°} < \bar{t}_T < t_{T,80°},$$

and for the frequency of 1000 Hz we have

$$\bar{t}_T < t_{T,0°} < t_{T,80°},$$

and finally for the frequencies of 2000 Hz and 4000 Hz the average values of $\bar{t}_T$ are in a relatively good agreement with the values of t_T measured at the determined initial phase. In these frequency range the effect of the initial phase on the tone-pitch duration threshold has not been observed.

The empirical approximative formula (2) evidently cannot fit the values of t_T with the precisely determined initial phase, e.g. t_T at the frequencies of 250 Hz and 500 Hz with the initial phase 0°, the second term of the right-hand side of the equation (2) should be less than 6.8 (see Table 1) and the term t_T at the initial phase of 80° should be large than 6.8 It follows from the experimental results that the threshold for the tone-pitch at a certain intensity level in the frequency interval of 125 Hz to 1000 Hz represents a function of two variables $t_T(f, \varphi)$ i.e. the frequency and the initial phase angle [5, 6]. More

Table 1

f [Hz]	$\bar{t}_T$ [msec]	φ	t_T [msec]
125	28.4	0°	23.1
		80°	28.5
250	17.6	0°	15.2
		80°	18.4
500	12.2	0°	11.7
		80°	13.8
1000	9.5	0°	10.9
		80°	11.2
2000	9.5	0°	8.8
		80°	9.1
4000	9.5	0°	9.1
		80°	9.0

f represents the frequency, $\bar{t}_T$ — the mean values of the tone-pitch duration threshold, φ — the initial phase angle and t_T is the tone-pitch threshold with the initial phase equal to 0° and to 80° (after [6]).

experimental data are necessary to determine the more exact form of the function $t_T(f, \varphi)$. With these data it would be possible to express the dependence of the tone-pitch duration threshold even on the initial phase angle. The determination of such a function vould mean a remarkable progress both in the description of the auditory system as the sensory communication channel and the determination of the specific information content of the tonic signals presented in [4].

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