Subdivision of the Audible Frequency Range into Critical Bands (Frequenzgruppen)

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Letters to the Editor

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THE subdivision of the frequency range over which the human ear is able to perceive tones and noises is often desirable for the handling of various problems. For mathematical and physical purposes it is useful to divide the scale either linearly or geometrically (logarithmically) as, for example, into octave and third-octave bands. Some problems, on the other hand, call for a subdivision more closely related to the manner in which the ear itself appears to carry out the process. Here the subdivision into critical bands seems to be very useful. These bands have been directly measured in experiments on the threshold for complex sounds,[1] on masking,[2] on the perception of phase,[3] and most often on the loudness of complex sounds.[4-7] In all these phenomena,[8,9] the critical band seems to play an important role. It must be pointed out that the measurements taken so far indicate that the critical bands have a certain width, but that their position on the frequency scale is not fixed; rather, the position can be changed continuously, perhaps by the ear itself. Furthermore, the subdivision into critical bands seems to be correlated very closely to the cochlear mechanics, to frequency discrimination, and to the mel scale of pitch. Between the critical ratio described by Fletcher[10] and the critical band (Frequenzgruppe) described here exist some relations but also some differences.[5]

At the I.S.O. meeting at Stockholm in 1958, the resolution was adopted to prepare a proposal concerning the limits of auditory critical bands (Frequenzgruppen) and to make it consistent with the "preferred frequencies." This proposal would be useful in

TABLE I.

Number	Center frequencies Hz	Cut-off frequencies Hz	Bandwidth Hz
		20	
1	50	100	80
2	150	200	100
3	250	300	100
4	350	400	100
5	450	510	110
6	570	630	120
7	700	770	140
8	840	920	150
9	1000	1080	160
10	1170	1270	190
11	1370	1480	210
12	1600	1720	240
13	1850	2000	280
14	2150	2320	320
15	2500	2700	380
16	2900	3150	450
17	3400	3700	550
18	4000	4400	700
19	4800	5300	900
20	5800	6400	1100
21	7000	7700	1300
22	8500	9500	1800
23	10 500	12 000	2500
24	13 500	15 500	3500

the further development of loudness-calculation procedures based on critical bands.

The proposal was prepared, and, although at the I.S.O. meeting in Rapallo in 1960 further discussions of this proposal were deferred, its publication was recommended. This seemed desirable in order to make the values available to interested people and to ensure that measurements and calculations based on critical bands will be comparable among themselves.

Table I gives the values for preferred frequencies defining the limits of auditory critical bands (Frequenzgruppen). The lowest limit has been set at 20 Hz for practical use. Since the direct measurements of the critical bands are subject to error, the values have been generously rounded, in such a way that critical bands 3, 9, and 18 have center frequencies of 250, 1000, and 4000 Hz.

Figure 1 shows the complete relation between a critical-band function and frequency. This critical-band function is based upon the natural division of the audible frequency range by the ear. We have proposed as a unit the "Bark," in memory of Barkhausen, the creator of the unit of loudness level. A difference of 1 Bark corresponds to the width of one critical band over the whole frequency range, and also corresponds very nearly to a pitch interval of 100 mels. The present proposal, as only one of many possible subdivisions, gives the critical-band numbers as the ordinate at the right side of the figure.

[1] G. Gässler, Acustica 4, 1, 408 (1954).
[2] E. Zwicker, Acustica 4, 1, 415 (1954).
[3] E. Zwicker, Acustica 2, 3, 125 (1952).
[4] E. Zwicker and R. Feldtkeller, Acustica 5, 303 (1955).
[5] E. Zwicker, G. Flottorp, and S. S. Stevens, J. Acoust. Soc. Am. 29, 548 (1957).
[6] B. Scharf, J. Acoust. Soc. Am. 31, 783 (1959).
[7] S. Scharf, J. Acoust. Soc. Am. 31, 365 (1959).
[8] R. Feldtkeller and E. Zwicker, *Das Ohr als Nachrichtenempfänger* (S. Hirzel Verlag, Stuttgart, 1956).
[9] E. Zwicker, Acustica 6, 365 (1956).
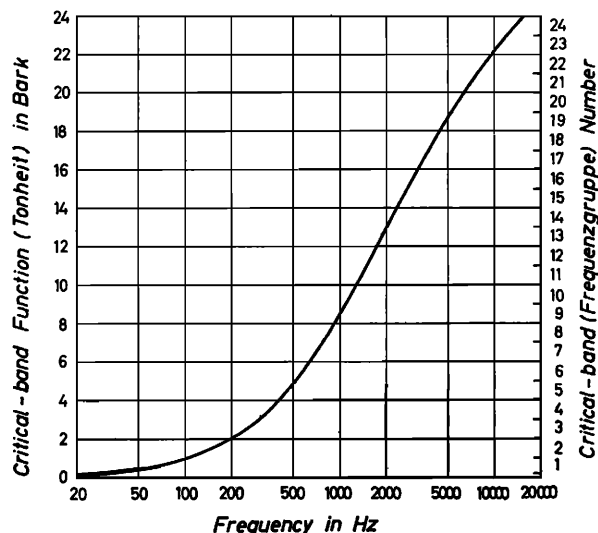[10] H. Fletcher, Revs. Modern Phys. 12, 47 (1940).

FIG. 1. Relation between the critical-band function and the frequency. The ordinate scale at the right side gives the critical-band numbers of the present proposal.