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Critical Bands and Filter Characteristics in the Ear of the Housemouse (*Mus musculus*)

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Abstract. Critical ratios (CRs) and critical bands (CBs, measured by narrow-band masking) were determined in one and the same test-procedure in 9 housemice (*Mus musculus*). Two spectrum levels of white band-pass noise (0 dB, 20 dB) and 9 frequencies between 2 kHz and 60 kHz were tested. CBs and CRs follow generally the same frequency-dependent functions. At 2 kHz the width of CRs is significantly larger ($p<0.01$) than the width of CBs, at 15 kHz CRs are smaller than CBs ($p<0.05$). At all other frequencies no significant differences ($p>0.05$) appear. No individual animal tested had significantly larger or smaller CBs ($p>0.05$) throughout the frequency range than the others. Critical bands represent equidistant parts of about 1 mm on the basilar membrane of the mouse. The steepness of the slopes of the CB-forming filter is directly proportional to frequency in the range from 10 kHz to 50 kHz. The critical band related distribution of behaviorally measurable excitation along the basilar membrane of the mouse is shown for the tested range of noise bands and spectrum levels. Present results are in essential agreement with respective data for man.

Introduction

Critical bands are empirical phenomena which play an important role in many psycho-acoustical measurements (reviews in Scharf, 1961; 1970). The critical band width either defines a point of discontinuity in measuring acoustic functions (e.g. phase sensitivity: Zwicker, 1952; threshold of complex sounds: Gässler, 1954; loudness summation: Zwicker et al., 1957) or is used to interpret results on masking (e.g. Fletcher, 1940; Schafer et al., 1950; Greenwood, 1961a; Margolis and Small, 1975).

In the latter case the critical band is a result of a filtering process which is assumed to take place within the cochlea. Experiments in which wide-band noise is used for masking (Fletcher, 1940; Hawkins and Stevens, 1950; Zwicker and Feldtkeller, 1967) give indirect estimates for critical bands (CBs) called critical ratios (CRs) because band widths are calculated from intensity ratios. Direct estimates of CBs result from narrow-band masking (Schafer et al., 1950; Swets et al., 1962; Patterson, 1974; Margolis and Small, 1975) where band widths are calculated from the band-pass characteristics of a hypothetical CB-forming filter.

Up to now the critical band concept is mainly based on investigations of the human acoustic system. It is evident that very special characteristics of the acoustic system can be measured in detial in man because of the direct communication in psycho-acoustical experiments. If the critical band concept shall be useful as a central theory in hearing of vertebrates it has to be proven for to be applicable in other mammals.

Critical ratios have been measured in the cat (Watson, 1963), rat (Gourevitch, 1965), porpoise (Johnson, 1968), chinchilla (Seaton and Trahiotis, 1975) ringed seal (Terhune and Ronald, 1975), and housemouse (Ehret, 1975). Only results from cat and mouse are comprehensive enough (frequency- and intensity range, number of animals) for a detailed discussion with respective human data (see Ehret, 1975). Few measurements of critical bands are available for monkeys (Gourevitch, 1970) and chinchillas (Seaton and Trahiotis, 1975). These are not conclusive concerning the relation between the width of CRs and CBs compared with respective function for man.

The present study reports a method for behavioral measuring of CRs and CBs in one and the same test procedure for the housemouse. Thus comparisons of CRs and CBs for this species and with data for man become possible and may be used in further considerations about the mechanisms of critical bands. In addition some characteristics of the CB filter as a filter of psycho-acoustical excitation are presented and compared with those in man.

Materials and Methods

1. Animals

Male white laboratory mice (*Mus musculus*, outbred strain NMRI) aged 11–14 weeks served as test subjects. No deficiencies in hearing or behavior are known so far in NMRI-mice.

2. Apparatus

The experiments were conducted in a sound shielded room (430 cm × 210 cm × 230 cm) the inner walls of which were covered with sound-absorbing rock wool. Total background noise between 1 kHz and 20 kHz was maximally 28 dB (re 0.0002 dyn/cm^2, measured with a Bruel and Kjaer sound level meter 2203 with 4131 microphone). Background noise for higher frequencies could not be measured but was most probably below 28 dB.

Pure tones of known frequency (Kontron counter timer 400 B) were generated in an oscillator (Wavetek 132) and went through an attenuator (Hewlett-Packard 350 D) to channel I of an electronic switch. In the switch the pure tones were shaped into transient-free pulses of 1 s flat-top duration and additional rise and fall times of 100 ms (linear slope). White noise was produced in a random noise generator (General Radio 1390-B) and went through an attenuator (Hewlett-Packard 350 D) and two bandpass filters in series (Krohn-Hite 3500; Rockland 852) to channal II of the electronic switch. Both filters worked in a "flat amplitude" mode. The attenuation slope for the band-pass noise was 72 dB/octave at the output of the second filter. Passing the electronic switch the noise was mixed to the pure tones and the complete signal finally ran through a power amplifier (Exact 170) to one of the speakers. For frequencies $f \geqq 15$ kHz a modified electrostatic speaker after Kuhl et al. (1954) was used. The response of this speaker was flat within ± 2.5 dB from 15 kHz to 80 kHz and decreased by 4 dB from 15 kHz to 10 kHz. For testing frequencies below 15 kHz a dynamic speaker (Transco HTF 80/5) was used of which the frequency response was flat within ± 3 dB between 2 kHz and 18 kHz.

The sound pressure levels (SPLs) of the band-pass noise and pure tones were measured independently by a calibrated 1/4″ microphone (Bruel and Kjaer 4135). The microphone output was amplified (Hewlett-Packard 466 A), filtered (Krohn-Hite 3500) and read on a storage oscilloscope (Tektronix 5103 N). All SPLs are given in dB re 0.0002 dyn/cm^2. For band-pass noise the intensity is expressed as the spectrum level (L_{WN}; see Zwicker and Feldtkeller, 1967). SPLs were always measured with ± 1 dB accuracy at the place of the animal's head in the test. The averaged distance between speaker and head was 30 cm.

3. Conditioning Procedure

The animals (Ss) were trained to show a conditioned eyelid-reflex on tones. The Ss were situated in a cage (13 cm × 3 cm × 4 cm) made out of metal bars (∅3 mm). Through the bottom an electro-shock (UCS) of 40 V AC and 0.5 s duration was administered. On every shock the Ss reacted with closing the eyes (eyelid-reflex, UCR). The Ss were trained with tone-shock-pairs (10 kHz, 70 dB tone of 1 s duration, terminated by the electro-shock) until they invariably produced the reflex (CR) on tone stimulation (CS) alone. Training sessions lasted for 10 min in which about 20 tone-shock-pairs were presented. Intertrial intervals varied between 3 s and 60 s depending on the behavior of the animal: good and reproducible responses could only be elicited if the animals were sitting motionless in the cage when the CS was presented.

This kind of conditioning continued during 8 days with one session per day. Then white noise (band width 1–80 kHz) with 10 dB spectrum level (L_{WN}) was introduced. Now the animals had to differentiate the *CS* from a noisy background. Conditioning with the signal combination continued for another 5 days. Then preliminary threshold tests were conducted in which 9 from 14 Ss at the beginning reached the values of the already known critical ratios for the mouse (Ehret, 1975). These 9 best responding Ss were selected for the tests.

4. Combined Measurement of CBs *and* CRs

Critical ratios are measured under broad-band noise conditions. Critical bands can be directly observed by determinating the relation between the thresholds of pure tones centered in a narrow-band masker of variable width and the band width of the masker. If the noise band widens, while keeping the spectrum level constant, the threshold of a pure tone in the center of the noise rises. Threshold increase will continue until the noise band passes beyond a certain width and then will remain constant. This width is equal to the critical band width. The constant threshold level for the larger noise bands than the critical, however, defines the critical ratio. Thus CRs and CBs can be determined in one and the same test either by increasing band width around a center frequency from narrow to wide-band or by narrowing the masking noise bands from wide-band to subcritical bands. In both cases thresholds have to be measured in dependence of the band width of noise. From the measured data CRs and CBs can be calculated. In the present study the band-narrowing procedure was employed.

5. Test

CBs and CRs were measured in 9 animals at the following frequencies (in the sequence of testing): 10, 5, 2, 20, 40, 60, 15, 30, 50 kHz. Two L_{WN} (0 dB and 20 dB) were tested at each frequency at successive days. Only one test session was held per day to keep the stress of the animals small.

An important factor in selecting the test procedure is the available test time. Most animals showed either aggressive behavior or apathy after about 15 min in test so that threshold measurements had to be finished within this time. Keeping that in mind and on the assumption that in every test session the CR and CB should be determined for one frequency and one L_{WN} the following procedure was applied: In pre-tests thresholds for two band-pass noises (2–18 kHz, 10–80 kHz, related to the two speakers) were roughly estimated. Then threshold measurements for the above mentioned frequencies started beginning with a band width of the masking noise mostly in the same magnitude as the frequency, for example, at 30 kHz a 30 kHz-band, band limits at 15 and 45 kHz. If the threshold for this band width reached the one for broad-band noise in the pre-tests, respectively the previously (Ehret, 1975) measured, the tests were continued with smaller noise bands. Band widths were reduced symmetrically to the mid-frequency in steps reaching 1 kHz in the critical region.

Thresholds were determined by a modified method of limits. At a given band width the SPL of the test tone was decreased in 5 dB-steps starting at the pre-estimated level or at the threshold level of the next larger band width. The Ss had three sequential trials at each SPL-step. As the threshold at a given band width the lowest SPL was defined to which a S responded positively (eyelid reflex) at least in two of the three trials; if a SPL was positively responded to in all three trials and the next 5 dB smaller one only in one trial the larger SPL was taken as the threshold (criterion). With this procedure 7–10 band widths at one frequency and L_{WN} could be tested for each S in one session.

Table 1. Mean values and standard deviations of masked thresholds (L_{MT}) for largest band widths and related CRs for all frequencies and noise levels tested

f [kHz]		2	5	10	15	20	30	40	50	60
0 [dB]	L_{MT} [dB]	40.0	34.4	36.5	34.0	40.3	41.1	42.6	44.8	45.6
L_{WN}	SD	3.5	3.0	3.8	3.5	3.5	3.3	3.9	3.6	3.0
	CR [dB]	same values as L_{MT}								
20 [dB]	L_{MT} [dB]	59.5	54.7	56.3	54.2	59.9	60.5	62.5	64.9	64.5
L_{WN}	SD	3.0	2.5	2.5	3.6	2.2	3.9	3.0	3.3	2.2
	CR [dB]	39.5	34.7	36.3	34.2	39.9	40.5	42.5	44.9	44.5

Results

1. Size of CRs

Table 1 shows the mean values and standard deviations of the constant levels of the masked tresholds (L_{MT}) for large band widths at all frequencies and noise levels tested. CRs can be calculated from these thresholds using the equation (see Ehret, 1975):

$$\mathrm{CR}\ (\mathrm{dB}) = L_{MT} - L_{WN} \qquad (1)$$

The respective CRs are also tabulated in Table 1. It is obvious that the CRs are independent of the L_{WN} in the measured range because they are practically identical for a given frequency. The CRs can be expressed in kHz following the relation (Ehret, 1975):

$$\mathrm{CR}\ (\mathrm{kHz}) \triangleq 10 \exp \frac{\mathrm{CR}\ (\mathrm{dB})}{10} \qquad (2)$$

The respective CR-values in kHz are shown as the mean from 0 dB and 20 dB L_{WN} in Figure 3.

2. Size of Mean CBs

Figure 1 shows relative threshold levels in dependence on frequency and the respective band width of noise. Threshold levels are averaged from 0 dB and 20 dB L_{WN}. The abscissa presents the extension of the basilar membrane with the respective frequency representation for the housemouse calculated after Ehret (1975). The threshold decrease from the constant levels for wide-band noise to narrow-band noise can be fit by straight lines. The intersections of these lines with the horizontal lines of constant thresholds can be defined as the corner frequencies of the respective critical bands. Mean CBs, however, were calculated from the functions in Figure 2, where relative thresholds are plotted against the band widths of the masking noise with frequency as parameter. Regression lines can be drawn ($p<0.01$ for correlation coefficients at all frequencies tested) that show a linear decrease in thresholds (in the logarithmic plot) for noise bands smaller than the critical. As the critical band width for one frequency the intersection of the regression

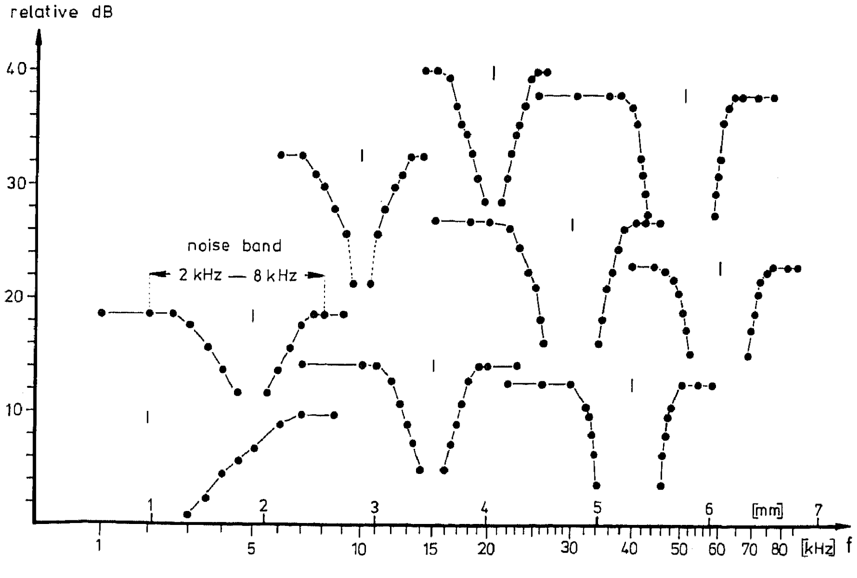

Fig. 1. Measured masked thresholds (ordinate) expressed in relative dB for each mid-frequency (vertical bar) and noise band width. The abscissa presents the extension of the basilar membrane from apex (0 mm) to base (7 mm) with the respective frequency distribution calculated after Ehret (1975). The band widths of noise can be measured between two respective and equi-leveled points in the figures for each mid-frequency except for 2 kHz, where the lower cut-off was always at 100 Hz. Values for noise bands can be taken from the frequency scale

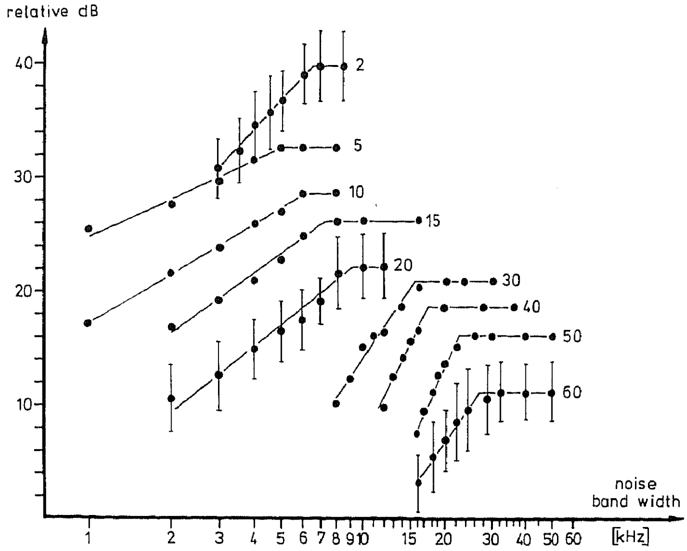

Fig. 2. Measured masked thresholds (averaged for 0 dB and 20 dB L_{WN} and expressed in relative dB) in dependence on the noise band widths (abscissa, logarithmic scale) with frequencies as parameters. For 2, 20, and 60 kHz standard deviations are presented. At the other frequencies they are in the same magnitude but are omitted for clearness

Table 2. Mean CBs in kHz calculated from regression lines in Figure 2 and respective slope values (dB/lg-unit) of the regression lines

f [kHz]	2	5	10	15	20	30	40	50	60
CB [kHz]	6.3	5.3	6.3	7.9	10.0	15.8	17.1	22.9	27.9
slope	27.1	10.1	13.9	16.0	17.3	34.2	54.1	57.8	39.6

line with the constant level for larger band widths was defined and the value calculated from the regression line. Table 2 presents the calculated CBs together with the respective slopes (in dB/lg-unit) of the regression lines. CB-values and slopes are plotted against frequency in Figure 3.

3. *Size of Individual* CBs

It is unadvisable to calculate individual CBs from individual regression lines of decreasing thresholds because thresholds were measured in 5 dB-steps with the result of a discontinuous function. Therefore individual CBs were defined as the smallest band width for which the constant threshold level was reached.

Table 3 shows the individual CBs (averaged for 0 dB and 20 dB L_{WN}) for all 9 Ss at each test-frequency. It was tested whether CBs from all frequencies were significantly different among the subjects. From a Wilcoxon rank-test (Sachs, 1974) followed that no animal had significantly larger or smaller critical

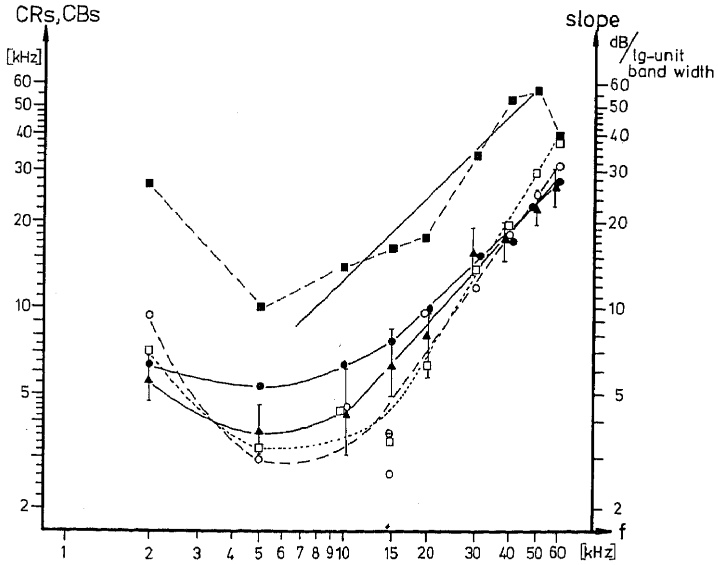

Fig. 3. Double-logarithmic plot of the frequency dependence of the width of critical ratios (CRs) and critical bands (CBs; left ordinate) and of the slopes from the regression lines in Figure 2 (right ordinate). Smoothed curves were drawn for CR- and CB-functions. For mean CBs* standard deviations are presented. ——●—— mean CBs from mean masked thresholds, ——▲—— mean CBs* from individual CBs, ––○–– mean CRs, present study, ------□------ mean CRs averaged for 0 dB and 20 dB L_{WN} from Ehret (1975), ⊖ corrected value at 15 kHz for CRs, present study, ––■–– values of the slopes from the regression lines in Figure 2

Table 3. Individual CBs in kHz (averaged for 0 dB and 20 dB L_{WN}) for all 9 Ss at each test frequency

f [kHz]		2	5	10	15	20	30	40	50	60
Ss	1	5.2	4.5	5.5	7.0	8.0	15.5	15.5	26.0	26.0
	2	5.4	4.5	3.5	5.0	7.5	15.0	24.0	23.0	24.0
	3	5.9	4.5	5.0	6.5	9.0	15.0	18.0	19.5	32.0
	4	4.2	4.0	5.0	5.0	8.5	17.0	14.0	23.0	23.0
	5	5.4	3.0	4.0	7.0	8.0	15.0	15.0	19.5	22.0
	6	6.4	3.5	4.0	5.0	8.0	17.0	20.0	23.0	30.0
	7	6.4	4.0	6.0	7.0	8.0	18.0	17.5	21.0	25.0
	8	5.2	4.5	4.0	7.0	8.0	12.5	17.5	22.0	28.0
	9	6.4	2.5	3.0	8.0	6.5	16.0	18.0	24.0	28.0

bands throughout the frequency range than the others ($p > 0.05$ in each pair of tested Ss).

In Figure 3 CBs* averaged from individual CBs are plotted against frequency.

Discussion

1. Comparison of CRs *and* CBs *in the Mouse*

In Figure 3 four functions are presented showing the frequency dependence of critical bands. The two CB-functions are the result of different evaluation of the same measured thresholds: mean CBs from mean masked thresholds (see Table 2) and mean CBs* averaged from individual CBs (Table 3). Differences of maximally 2 kHz appear which are in the same magnitude of pre-settings of the noise band widths. It should be mentioned that a difference of 2 kHz means a factor of about 1.5 at 5 kHz and a factor 1.0 at 50 kHz.

Mean CBs* from individual CBs are more reliable because they are averaged over the band width scale which was preset in steps of 1–4 kHz (depending on the test-frequency), whereas mean CBs were averaged over the SPL-scale with pre-settings of 5 dB at all frequencies. A 5 dB difference in the present range of thresholds means, transformed into kHz, about a 7 kHz variation at 5 kHz and a 70 kHz variation at 50 kHz. On the basis of the standard deviations in Figure 2 which mostly are in the magnitude of ± 3 dB one could calculate deviations for the CB-values in Figure 3, which would be extraordinary large and would tell only little about the real variation of measured CBs. Standard deviations of mean CBs* (Fig. 3) are a more adequate measure of variation for critical bands because they base on the sharper method of data evaluation.

The CR-functions (mean data of the present study and mean data of 0 dB and 20 dB L_{WN} from Ehret, 1975) are not significantly different at any frequency ($p > 0.1$).

The CR-value (present work) at 15 kHz has to be corrected for about +1 dB, because the emitted SPLs by the electrostatic speaker decreased for frequencies below 15 kHz (see apparatus). This leads to some threshold decrease in wideband noise conditions (CR-measurements) which must be considered.

Now, comparing the CR- and CB*-functions determined in the present study two points seem to be important: a) CRs and CBs* follow generally the same functions. b) CRs are significantly different ($p < 0.01$, rank-test) from CBs* at 2 kHz and 15 kHz. At all other frequencies no significant differences appear ($p > 0.05$). If one tests, however, the corrected value for CRs at 15 kHz against the CB*-value, only a weak significance level of $p < 0.05$ occurs.

It can be concluded from the present data that in the mouse critical bands derived from wide-band (CRs) and from narrow-band masking have actually the same widths. An exception are CRs at 2 kHz which are larger than CBs and CRs at 15 kHz which possibly are smaller than CBs.

Figure 1 shows the frequency distribution on the basilar membrane of the mouse as calculated from CRs after Ehret (1975). Measuring the geometrical width of CBs in Figure 1, it can be seen that CBs represent equidistant parts of about 1 mm on the basilar membrane. This is a confirmation for the formular of frequency representation on the basilar membrane (Ehret, 1975) and again agrees with respective human data (Zwicker, 1956; Greenwood, 1961b; Zwicker and Feldtkeller, 1967).

2. Comparison with Other Species

The present results on *Mus musculus* can be compared in detail only with respective data on man. Doing this one has to distinguish between two main sets of experiments for measuring CBs in man (see introduction): those using pure tones, e.g. in loudness summation and two-tone masking, and others using narrow-band noise as a masker. CBs from narrow-band masking were mostly found to have similar widths as CRs derived from wide-band masking (Fletcher, 1940; Hawkins and Stevens, 1950; Schafer et al., 1950; Swets et al., 1962; Patterson, 1974; Margolis and Small, 1975), whereas CBs from pure tone studies are about 2.5 times larger than CRs (Zwicker et al., 1957; Scharf, 1970). An exception are Greenwood's (1961a, b) measurements with narrow-band noise. The CBs from his study agree with those from pure tone experiments.

In the present study for the housemouse CBs are measured by narrow-band masking and, compared with respective CRs, the same relation holds as in man, i.e. CRs and CBs do generally not differ significantly.

Seaton and Trahiotis (1975) measured CBs (narrow-band masking) and CRs at four frequencies in the chinchilla. They found that CBs were larger than CRs by a factor of about 2.5 at 0.5 and 1 kHz. At 2 and 4 kHz, however, CBs and CRs were practically identical. This result differs from those of man and mouse. The disagreement may be due to methods of testing and data evaluation by Seaton and Trahiotis (1975). In their threshold tests attenuation steps for the SPL were 10 dB which seems to be large for determinating differences of 4 dB between averaged data significantly. On the other hand one can evaluate the mean data for CBs (Table 3, Seaton and Trahiotis, 1975) in the same way as done in the present study by calculating regression lines for the determination of CBs. Result is that the thus gained CBs for chinchillas are 4–5 times larger than the CRs at each of the four test-frequencies. This would mean that in the chinchilla CBs from narrow-band masking experiments behave as CBs from pure tone studies in man.

Gourevitch (1970) measured CBs at some frequencies for two monkeys using either two-tone masking or narrow-band masking. He found that the CBs fitted into one function being actually the same as the CB-function (pure tone studies) for man. Gourevitch (1970) stated that the measured CBs in the monkey are 2.5 times larger than CRs. This again would mean a difference to measurements in man where in most cases only CBs from pure tone experiments are 2.5 times larger than CRs.

Differences in the measured relations between CRs and CBs can partly be explained by methological influences as mentioned before. Schafer et al. (1950), Swets et al. (1962), and Patterson (1974) showed that the width of CBs in narrow-band masking strongly depends on data evaluation especially on the postulated shapes of the auditory filter responsible for CB-forming. As critical bands are empirical phenomena which could not yet be related to definite structures of the cochlea or to neural processes it is not possible to speak of "the critical band". Present and previous (Ehret, 1975) measurements showed, however, that a critical band mechanism is obviously working on a common basis in man and mouse, psychologically different methods of testing are not decisive in measuring the selectivity of the ear for the analysis of complex sound.

3. Some Characteristics of the CB-forming Filter

From the present measurements filter characteristics and filter shapes can be indirectly determined.

Figure 2 shows masked thresholds (L_{MT}) in dependence on the respective noise bands. If one expresses the band width (BW) in dB, the regression lines follow the general function:

$$L_{MT} = c \cdot \mathrm{BW}\,(\mathrm{dB}) + b \tag{3}$$

Equation (3) is defined for BW $\leqq$ CB. The slope values of the regression lines (compare Table 2) are an indirect measure for the quality of an internal filter. The steeper the slopes the greater is the effect of band width variation on masked thresholds. As shown by Zwicker and Feldtkeller (1967) and Zwicker (1970) masked thresholds are a measure of the psycho-acoustical excitation level (L_E), thus band width variation means variation of excitation, and the internal filter determines the sharpness of the transforming process in the frequency domain.

In Figure 3 the slope values of the regression lines from Figure 2 are plotted against frequency. Between 10 kHz and 50 kHz the function can be approximated by a straight line with the equation:

$$\lg c = 0.97 \cdot \lg f - 2.79 \tag{4}$$

solved for c:

$$c = 0.0016 \cdot f^{0.97} \tag{5}$$

The exponent for f in Equation 5 is practically equal to 1 so that follows, generally:

$$c = k \cdot f \tag{6}$$

The slope, i.e. the sharpness of tuning in the CB-forming filter is proportional to frequency between 10 kHz and 50 kHz. This relation becomes evident in Figure 1. A threshold increase per unit increase in band width is very much larger at high frequencies compared with low ones. It can be directly recognized on the abscissa in Figure 1 that an increase in band width leads to a smaller spread of excitation on the basilar membrane at higher frequencies than at lower ones.

The single figures at each center frequency in Figure 1 can be seen as filter shapes indicating the spread of excitation along the basilar membrane with increasing level. The relative threshold level of the masked tone (ordinate) can be changed according to Zwicker and Feldtkeller (1967) into the relative excitation level and the given band widths of noise change into band widths of excitation. This consideration

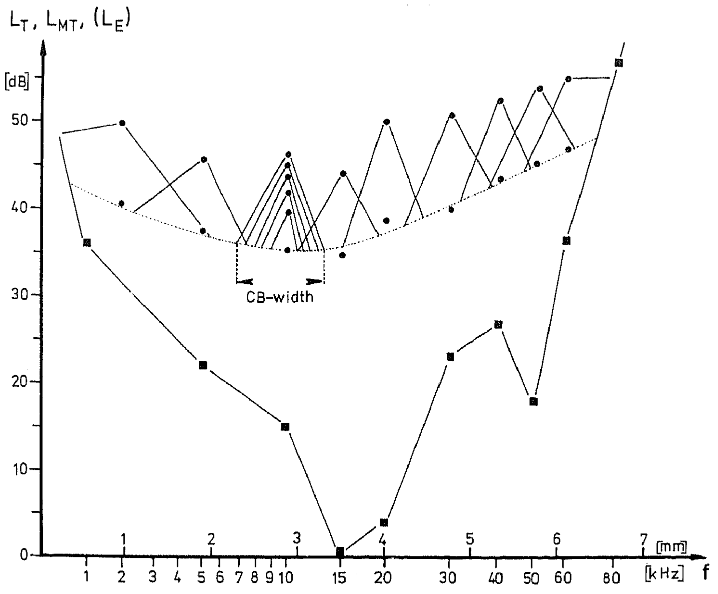

Fig. 4. Distribution patterns of excitation within single critical bands along the basilar membrane (abscissa, same as in Fig. 1). Filled squares mark absolute auditory thresholds (L_T; Ehret, 1974) of *Mus musculus*. Further explanations, see text

postulates that the shape of the noise band (in the present case: flat top and 72 dB/octave attenuation) is linearly transformed into excitation. Human data (Zwicker and Feldtkeller, 1967) show that a linear relation can only be assumed for low excitation levels (up to about 40 dB). In the present study masked thresholds for 0 dB L_{WN} fit this condition and excitation at thresholds for 20 dB L_{WN} will be only little influenced by nonlinearities.

The data from Figure 1 can be transformed into Figure 4 where the distribution of behaviorally measurable excitation along the basilar membrane of the mouse becomes evident. The ordinate scale stands for the threshold level of absolute auditory thresholds (L_T; Ehret, 1974, 1976) and masked thresholds (L_{MT}), measured in the present study (averaged from 0 dB and 20 dB L_{WN} and then related to 10 dB L_{WN}). If it is assumed that masked threshold levels are proportional to excitation levels which nearly is the case in man (Zwicker and Feldtkeller, 1967), then the ordinate scale is also a measure for the excitation level (L_E). The dotted line (Fig. 4) is a smoothed curve indicating the level of masked thresholds (or excitation) on which the present measurements started. The lower filled circles are the precise values at each test frequency. These threshold values correspond to noise band widths (excitation band widths) of 3 kHz at 2 kHz test frequency, of 1 kHz at 5 and 10 kHz, of 2 kHz at 15 and 20 kHz, of 8 kHz at 30 kHz, of 12 kHz at 40 kHz, and of 16 kHz at 50 and 60 kHz. At 10 kHz it is demonstrated how the L_{MT}-values (L_E-values) increase with increasing band width of noise (band width of excitation) until the CB-width is reached, where the threshold levels (excitation levels) remain constant (upper filled circles). In analogy to man (Zwicker and Feldtkeller, 1967; Zwicker, 1970) it can be stated that the area of each triangle represents the integral of sound intensity falling within one critical band and leading to the shown increase of threshold- or excitation-level. Figure 4 can be directly compared with Figures 21,2; 43,1; 43,2; and 43,3 in Zwicker and Feldtkeller (1967), considering however, that in the present case measurements did not start at the absolute threshold but at masked thresholds due to subcritical noise bands (dotted line in Fig. 4).

In conclusion, the present data show evidence for a basically identical critical band mechanism, i.e. a psychoacoustically measurable filter, in the ear of man and mouse.

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