Interaural correlation sensitivity.

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Abstract: Sensitivity to differences in interaural correlation was measured as a function of reference interaural correlation and frequency (250 to 1500 Hz) for narrowband-noise stimuli (1.3 ERBs wide) and for the same stimuli spectrally fringed by broadband correlated noise. d' was measured for two-interval discriminations between fixed pairs of correlation values, and these measurements were used to generate cumulative d' versus correlation curves for each stimulus frequency and type. The perceptual cue reported by subjects was perceived intracranial breadth for narrowband stimuli (wider image for lower correlation) and loudness of a whistling sound heard at the frequency of the decorrelated band for the fringed stimuli (louder for lower correlation). At low correlations, sensitivity was greater for fringed than for narrowband stimuli at all frequencies, but at higher correlations, sensitivity was often greater for narrowband stimuli. For fringed stimuli, cumulative sensitivity was greater at low frequencies than at high frequencies, but listeners produced varied patterns for narrowband stimuli. The forms of cumulative d' curves as a function of frequency were interpolated using an eight-parameter fitted function. Such functions may be used to predict listeners' perceptions of stimuli that vary across frequency in interaural correlation.

Recent theories of binaural unmasking have emphasized the role of interaural decorrelation (1-ρ). When an out-of-phase signal is added to a more intense, in-phase noise (NoSπ) the interaural correlation (ρ) of the stimulus is reduced at the signal frequency, and this reduction is detected by the listener and heard as a faint tone, or, if the noise is sufficiently narrowband, as a broadening of the sound image. Provided the signal is less intense than the masker, 1-ρ is monotonically related to the strength of the signal (1); the more intense the signal the higher 1-ρ. This fact raises the possibility that listeners may be able to use 1-ρ as an index of the signal intensity, as well as for signal detection. When attending to spectrally rich sounds, such as speech in noise, accurate recovery of the signal spectrum by the binaural system will require an assay of the signal intensity at each frequency.

In the present experiments, listeners' sensitivity to differences in ρ was measured and converted into a cumulative d' function, $d'_{(\rho,1)}$, reflecting the discriminability of correlations ρ and 1, using two types of stimuli. One stimulus was a 1.3-ERB-wide (2) noise-band. The other was the same band spectrally fringed with correlated noise (total bandwidth = 0-3 kHz). These stimuli were analogous to NoSπ stimuli made with narrowband and with wideband noise, respectively, and evoked similar percepts; decorrelating the narrowband stimuli produced a progressively wider intracranial sound image, while decorrelating the fringed stimuli produced a progressively louder whistling noise at the frequency of the decorrelated band. The latter observation is consistent with the hypothesis that 1-ρ acts as a cue to signal intensity. Listeners heard two batteries of 50 two-interval trials at each frequency and for each pair of ρ values. Discriminations were made between pairs of values from the following sets: for fringed stimuli, 0.0, 0.3, 0.5, 0.65, 0.8, 0.9, 1.0; for narrowband stimuli, 0.0, 0.5, 0.7, 0.8, 0.9, 0.95, 1.0. Fifteen pairs spanned up to three intervals between these values. Decorrelated bands were centered at 250, 500, 750, 1000, 1250 and 1500 Hz. Functions relating $d'_{(\rho,1)}$ to ρ were generated by finding the parameters which best predicted the measured d's.

The results from fitting the 90 averaged d' values from six listeners have been summarised in Figure 1a) which shows a surface plot of $d'_{(\rho,1)}$ as a simultaneous function of frequency and interaural correlation for fringed stimuli. Figure 1b) shows a similar plot for the most proficient listener so far tested with narrowband stimuli. The interaural correlation axis has been converted into equivalent signal-to-noise ratio using Eq. 1:

$$S/N = (1-\rho)/(1+\rho)\,. \qquad (1)$$

The surface is described by a family of exponential curves of the following form:

$$d'_{(\rho,1)} = \exp(n+k) - \exp(k\rho + n)\,. \qquad (2)$$

The two parameters, n and k, each change as a function of frequency, f, via a logistic function (Eq 3):

$$parameter = \frac{r}{1+\exp(s[f-t])} + a\,. \qquad (3)$$

The values of r, s, t, and a for parameters n and k, given in Table I, were fitted to the data to produce Figure 1.

TABLE 1. Fitted parameters

Stimuli	Parameter	*r*	*s*	*t*	*a*
fringed	*k*	3.67	0.0063	748	0.02
(n=6)	*n*	4.22	-0.0066	766	-2.40
narrowband	*k*	4.73	-0.0100	655	3.52
(n=1)	*n*	4.83	0.0094	691	-7.28

The results for narrowband stimuli have so far been collected for three listeners. However, the results were highly variable and, for two of those three, *d*'s were low compared with just-noticeable differences that have been reported in the literature (1,3). Consequently, only the most proficient listener's data are reported here. The fit accounts for 80% of the variance in his data.

The results for the fringed stimuli were more consistent and the fit accounted for 91% of the variance in the data. The results with fringed stimuli were considered to be of particular importance to the issue of speech understanding in noise. If $d'_{(\rho,1)}$ can be considered as a measure of loudness, then Figure 1a) suggests that signal intensity in dB is more or less linearly transformed into loudness in the binaural recovery process. The results of the fringed condition, therefore, support the idea that listeners may be able to use the spectral profile of 1-ρ as an index of the intensity of otherwise masked components of speech (4).

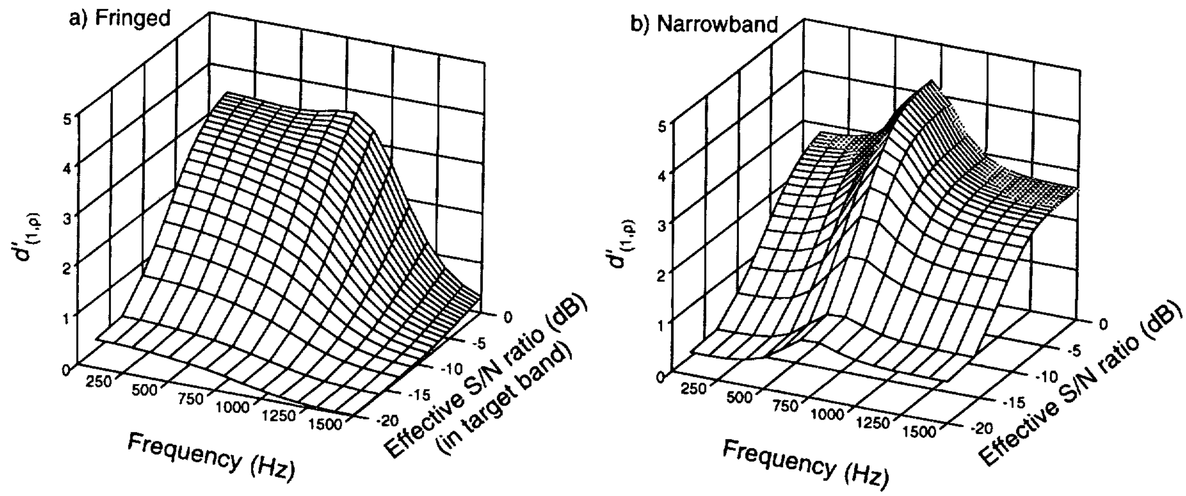

FIGURE 1. Fitted surface plots for $d'_{(\rho,1)}$ as a simultaneous function of interaural correlation and frequency. The fitted function is described by Eqs (2) and (3). The surface was fitted to the averaged raw data, for a) fringed stimuli (n=6), b) narrowband stimuli (n=1).

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