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## Spectral Dominance in Binaural Lateralization

Lateralization experiments have been carried out with filtered and unfiltered antiphasic clicks.

On the basis of a model where cochlear filtering takes place first and where the outputs of corresponding filters from both ears are compared, we may expect not the external time difference at both ears to determine the position of a lateralized image but rather the (frequency dependent) time difference between the major positive peaks in the outputs of corresponding cochlear filters.

For antiphasic clicks, for instance, the external time difference at both ears differs from the time difference between positive excursions in the output of corresponding filters in both ears by half the period of the filter centre frequency (compare FLANAGAN et al. [1]).

So, in this line of thought we might expect the lateralization of narrow-band clicks to be very well defined as opposed to that of wide-band clicks, whose spectral energy covers a wide range of different cochlear filters. Yet, for wide-band antiphasic clicks, in general a distinct lateralized image is perceived. Consequently a particular frequency region may be expected to exist that dominates with respect to lateralization over all other possible frequency regions.

In order to test these hypotheses, listening tests were performed. Subjects were asked to adjust the position of the lateralized (or centralized) image of pairs of wide-band or third-octave bandpass filtered clicks with opposite polarity and adjustable interaural delay $\tau$ to the position of a reference image of (un)filtered clicks with equal polarity and fixed interaural delay.

For the third-octave clicks, the figure shows measured $\tau$-values and theoretical curves representing $\tau$ as a function of the third octave bandpass centre frequency $f_0$ according to the hypothesis of cochlear time fine-structure detection as mentioned above. Each measured point represents the average of at least 20 adjustments. Three subjects participated in the experiments. For a reference with delay zero (central image) the solid curve b gives the theoretical expectation. The dashed line fitted by hand to the measured points significantly deviates from this theoretical curve (this fact also has been reported by NORDMARK [2]).

The data for a reference with delay 0.5 ms (lateral image) are represented by the curves $a_1$ and $a_2$. Here the measured points and the theoretical expectation are in good agreement. Notice that according to the time-fine structure ambiguity above 1000 Hz is expected. Indeed, one subject reported a very distinct second image for a filter frequency of 2400 Hz (the circle in curve $a_2$ for 2400 Hz).

With unfiltered clicks, $\tau$-values were measured that are represented by the dash-dotted horizontal lines (the average values for the three subjects). Note that these wide-band values are equal to the narrow-band values obtained for a band filter centre frequency $f_0$ of about 650 Hz.

According to NORDMARK [2] analogies exist between lateralization and pitch perception. Indeed, the pitch of pulse pairs (or noise added to itself delayed) presented to one ear behaves in an analogous way: i. e. a possible way to describe the experimental pitch data is as though pitch results from the detection of the time difference between major positive peaks in the cochlear filter response in a particular frequency region that dominates over all other possible regions (BILSEN [3]). However, this description does not seem to be compatible with other facts on pitch perception, and probably it is not the way in which the hearing organ works with respect to pitch. Thus, with respect to monaural pitch, the analogy with lateralization seems to be only numerical, certainly not mechanistic.

On the other hand, a common feature seems to exist for both lateralization and the perception of pitch of dichotically delayed noise (Dichotic Repetition Pitch (BILSEN [4]). This pitch is the result of the dichotic presentation of white noise to one ear and the same noise delayed to the other ear, for interaural delay times larger than about 2 ms; it corresponds to the reciprocal value of the delay time. For unfilterd or wide-band signals, Dichotic Repetition Pitch appears to be determined predominantly by the spectral region (or cochlear filter output) with a centre frequency of about 625 Hz. This frequency region is called the

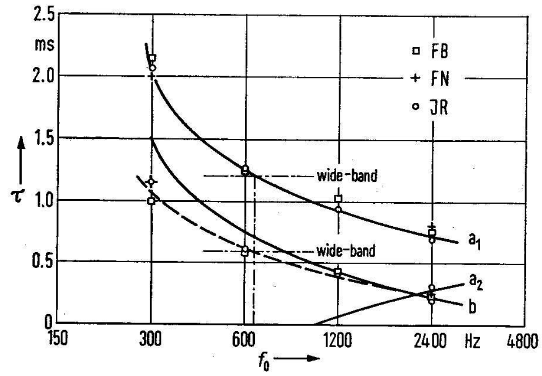


Fig. 1. The interaural delay time $\tau$ of unfiltered and filtered antiphasic clicks as a function of the band-pass centre frequency $f_0$ for a central (curve b) and a lateral image (curves $a_1$ and $a_2$).

dominant spectral region. The present lateralization experiments with wide-band antiphasic click pairs under the same conditions resulted in a similar dominant region for lateralization roughly between 600 and 700 Hz.

Thus we may conclude that there exists dominance of a particular spectral region, in which optimal binaural interaction seems to occur with respect to both dichotic pitch perception and lateralization. It is noteworthy that also optimal binaural beats occur approximately in the same region (LICKLIDER [5]). In near future, the spectral dominance phenomenon will be studied in more detail by measuring the strength of lateralization sensation for different frequency regions.

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