Basilar Membrane Excitation Patterns of Rough Sounds Simulated by Means of an Auditory Model *(no. p32)*

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Pure tone can be characterized to sound rough when it is amplitude or frequency modulated. Perception of roughness can also occur when two pure tones differing little in frequency are presented simultaneously. Hydrodynamical cochlear model simulating the basilar membrane response to sound stimulation is used to get the impression about the basilar membrane excitation patterns caused by rough signals. The model was designed to simulate the real behavior of the cochlea in small mammals, specifically magnitude and phase characteristics of cochlear filters obtained during physiological experiments. Model parameters were then adjusted to simulate the human cochlea. Since it is not possible to conduct in vivo experiments in human cochlea, the model was verified by means of psychophysical experiments. The model can much better than other types of cochlear models (e.g. widely used filterbank models) predict masking experiments with complex sound signals. Perception of roughness is often being associated with a situation when more spectral components falls into the same cochlear filter which is the case of complex sound signals used in the masking experiments. The hydrodynamical cochlear model was thus chosen to simulate the basilar membrane excitation patterns in response to rough sounds.

The model output was first obtain in response to two 60 dB SPL pure tones with gradually increasing frequency difference from 10 Hz to 140 Hz, lower tone fixed at 400 Hz. Strong amplitude modulation is visible in the excitation patterns up to 60 Hz frequency difference. Decomposition of the excitation patterns into two components and decrease of amplitude modulation depth is then obvious for higher frequency differences.
The second signal was composed of three harmonic components. Frequency of individual harmonics was 200, 400 and 600 Hz and levels 60, 40 and 30 dB SPL respectively. 300 Hz pure tone was added to the complex tone in order to cause a perception of roughness. Level of the pure tone was increased from 20 dB to 60 dB SPL. Excitation patterns without the pure tone show three separated vibrating regions on the basilar membrane. Each of them corresponds to one of the harmonics. Added signal causes pattern with 100 Hz period in the region between the first and second harmonic. This is accompanied by a perception of roughness.

The model was finally used to obtain excitation patterns of speech signals with and without roughness. Speech signals were recorded during videokymographical examination when the subjects were asked to produce sustained vowels. Continuous signals contained passages with roughness and passages without roughness. Diplophonia was examined as a cause of the roughness. Amplitude modulation can be again visible in the basilar membrane excitation patterns of rough signals. Disordered voices also causes irregular patterns in parts were more harmonic components fall into one cochlear filter.

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