Illusory Percepts from Auditory Adaptation

... a link between Tinnitus and Zwicker tone

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Tinnitus and Zwicker tone

Tinnitus:
• Associated with hearing loss
• Phantom “ringing” often at the frequency of loss.
• Not detected in the periphery and thought to involve central adaptation mechanisms.

Zwicker tone:
• Follows notched noise
• Short “ringing” percept at notched frequency
• Neural correlate unknown.

Gain adaptation

Simplest mechanism: Integrate power in some time window and normalize the signal to have unit power on that time scale.

Phantom percepts result for reduced input power

We reconstructed signal to give a sense of the “perception” after gain adaptation.

Assumption during reconstruction: Total power of the signal is encoded in separate channel. (Optimal encoding)

Information bottleneck

Acoustic signal
120dB
(a 20kHz < 40kHz)

Neural signal
20dB
20kHz < 6kHz

We postulate that an adaptation mechanism is required to optimally use the available information capacity.

Tinnitus and Zwicker tone

Hypothesis:
Central adaptation increases gain due to reduced input in hearing-loss band (or notched band) thereby magnifying internal noise that is perceived as “ringing”.

Minimal gain adaptation model

Model assumptions:
• Operates separately in each frequency band
• Internal additive noise
• Power integrated in time
• Divisive normalization

Why is the good for compression:
• Maximizes bit rate of an amplitude limited channel.
• Reduces redundancy of co-modulated frequency bands.

Psychophysics results

Results show first empirical link between Zwicker tone and tinnitus self report:
• One third of subjects reported recurring tinnitus percept.
• Half of normal subjects do not hear Zwicker tone.
• To our surprise model did only fail for normal subjects!

Conclusion:
• Tinnitus subjects perceive Zwicker tone differently than normals.
• Model seems adequate for tinnitus subjects.

New Prediction

We predict an intra-individual correlation between non-linear compression and elevated thresholds with Zwicker tone masking behavior.

We are currently in the process of testing this prediction and appreciate your discretion until the results are published.

Normal vs. Tinnitus subjects

Normal hearing subjects exhibit non-linear compression. When including (logarithmic) compression the model Zwicker percept is weaker and matches behavioral responses of normal subjects.

Summary of Adaptation Hypothesis

Limited bandwidth channel may necessitate gain adaptation.
When input is suppressed this adaptation magnifies internal noise to “fill the channel”, which is then perceived as phantom sound.

Zwicker tone masking behavior was predicted and confirmed for tinnitus subjects establishing an empirical link between the two phenomena.

Zwicker tone masking behavior differs for normal and tinnitus subjects and may be explained by loss of non-linear compression peripherally from the adaptation stage.