Illusory Percepts from Auditory Adaptation

… a link between Tinnitus and Zwicker tone

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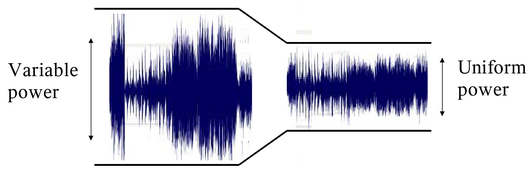
Tinnitus and Zwicker tone

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.

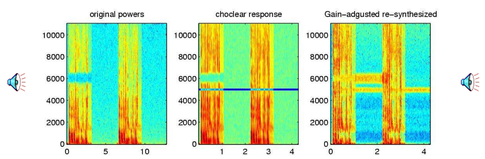
Gain adaptation

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

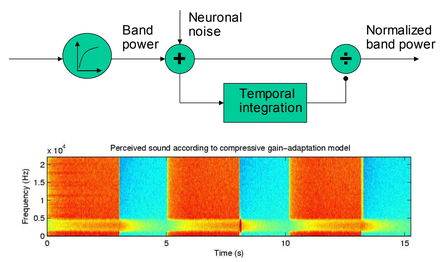
We reconstructed signal to gives a sense of the "perception" after gain adaptation.



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

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.



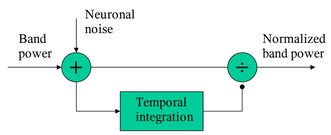
Tinnitus and Zwicker tone

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".

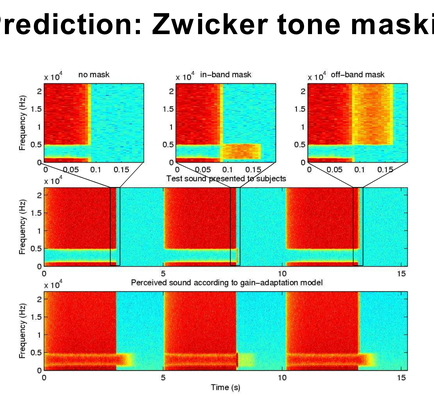
Minimal gain adaptation model

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.

Prediction: Zwicker tone masking



Summary of Adaptation Hypothesis

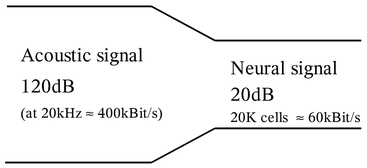
Limited bandwidth channel may necessitate gain adaptation.

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.

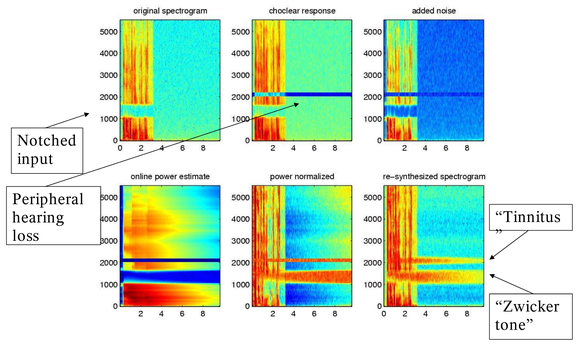
Zwicker tone masking behavior differs for normal and tinnitus subjects and may be explained by loss of non-linear compression peripherally from the adaptation stage.

Information bottleneck



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

Phantom percepts result for reduced input power



Psychophysics results

Results show first empirical link between Zwicker tone and tinnitus self report:

Tinnitus	Zwicker yes	Zwicker no	Zwicker total
yes	6	0	6
no	8	6	14
total	14	6	20

Table 1: Number of subjects reporting various combinations of tinnitus and Zwicker tone percept. None who reported tinnitus failed to report a Zwicker tone percept.

Tinnitus	Correct Prediction yes	Correct Prediction no	Correct Prediction total
yes	6	0	6
no	3	5	8
total	9	5	14

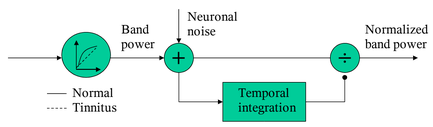
Table 2: Number of subjects for whom the non-compressive model correlated significantly with the behavioral response. The model predicted the response correctly for all subjects with tinnitus.

- One third of subjects reported recurring tinnitus percept.
- Half of normal subjects do not hear Zwicker tone.
- Model predicts behavioral response to mask for most subjects.
- 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 ☺.