Tinnitus status and spectral profile can be predicted from Audiogram and DPgram for a subset of subject

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Abstract:
We previously hypothesized that tinnitus is the result of a gain-adaptation mechanism that, when confronted with degraded peripheral input, increases neuronal gains such that spontaneous neuronal activity is perceived as a phantom sound. Following this hypothesis we predicted that the tinnitus percept can be determined for individual subjects from measures of their peripheral processing when obtained with sufficient frequency resolution. The aim of this ongoing study is therefore to find a correlation between the tinnitus percept with measures of peripheral processing on an individual subject basis. To assess peripheral processing, we measured Distortion Products Oto-Acoustic Emission (DPOAE) with high frequency resolution (160 points per octave) as well as band-pass audiograms (5 points per octave). The tinnitus percept was assessed using the well-established tinnitus-likeness test. This test asks subjects to rate how much their tinnitus resembles a pure tone or total noise at various frequencies thus providing a tinnitus spectrum. All measures were obtained in the frequency range of 1kHz to 18kHz. Preliminary results show that for a subset of subjects the tinnitus spectrum can indeed be predicted purely from these physiological measures (with p<0.05). The obtained in the frequency range of 1kHz to 10kHz. Preliminary results show that for a subset of subjects the

Results and discussion:

Model predictions:

1. Loss of peripheral compression is indicative of tinnitus status.
2. The precise properties of the tinnitus percept can be determined from thresholds and compression.

DPOAE, Audiogram and Tinnitus Likeness test:

Fig 4. Example data: Recorded 27 tinnitus subjects and 12 normal subjects.
Top row shows DPOAE data.
Middle row shows audiogram results.
Bottom row shows likeness spectrum test.

Fig 6. DPOAE improves diagnosis of Tinnitus Status
• Despite correlation DPOAE features and thresholds can be combined to estimate likelihood of tinnitus.
• DPOAE features provide significant information about tinnitus status over audiogram alone (p=0.04)
• Predicted tinnitus strength (log-likelihood) correlates with subjective tinnitus severity (p=0.04).

Subgroup of Tinnitus:
Why are some subjects “predictable” from their peripheral hearing deficits and other not?
• Unpredictable subjects can not reproduce their subjective likeness ratings thus the subjective data may be “too noisy” to predict.
• Subjects may have less hearing loss.

Conclusion:
Gain adaptation model explains known properties of Tinnitus:
1) associated with hearing loss
2) effect predominant at floor of loss-edge
3) Effect strongest for sharp loss-edge.
Theory also predicted:
1) Tinnitus subjects are more likely to hear the Zwicker tone.
2) DPOAE compression is diagnostic of tinnitus status, thus addressing one of the mysteries of Tinnitus.
3) Tinnitus spectrum can be predicted for most subjects when using DPOAE features in addition to audiogram.

References:

Subjects and Procedures:
• 27 tinnitus subjects and 12 normal subjects were recruited for this experiment.
• DPOAE generator component using continuous frequency sweep at various primary levels.
• Audiogram and tinnitus likeness test.

Table 1: Example audiogram and tinnitus profile results.

Table 2: Tinnitus likeness test results.

Table 3: DPOAE features and thresholds.

Model result consistent with data:

Fig 1. Schematic showing the computational model.

Fig 2. Effect of cochlea compression:
• Outer-hair cells in cochlea produce non-linear compression.
• Tinnitus correlates with reduced peripheral compression.

Fig 3. Zwicker tone correlates with tinnitus:
A related phantom percept with short time constant (<1s) is the Zwicker tone. According to our model it should be equally affected by loss of compression. Indeed we confirmed previously that Tinnitus subjects are more likely to hear the Zwicker phantom percept. (Parra, Pearlmutter, 2007)

Fig 5. Audiogram and DPOAE significant difference with Tinnitus and Normal subjects.
The left column shows the audiogram result. The middle column shows the mean DPOAE compression. The right column shows DPOAE compression.

Fig 8. Subgroup of Tinnitus:
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Fig 9. Tinnitus spectrum prediction:

Results and discussion:

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Spatial integration
Fig 1. Model explains known features of Tinnitus:
Percept frequencies match the hearing loss frequencies.

When including lateral inhibition the predominant percept is at the lower edge of the hearing loss.

Sharp edges produce stronger percept.