To address these questions, we use a time-domain implementation of a linear model of the cochlea that can be used to account for connections between otoacoustic emissions (Shera et al., 2001, JASA). The resulting tuning was quantified by numerically estimating the tuning, which is described in detail in Epp et al. (2010). The coupled equations of motion were solved in the time domain using a 4th-order Runge-Kutta method. A roughness was introduced by a random factor:

\[
\dot{x} = \ddot{x}(x, t) + \xi(x, t) \dot{x},
\]

\[
\ddot{x}(x, t) = m \ddot{x} + a(x, t) \dot{x} + c(x, t) \ddot{x} + \xi(x, t).
\]

where \(N(x, \infty)\) represents a normal distribution with mean 0 and variance of 1. For the simulation of population data, each subject was characterized by a unique roughness vector, but varied along x (e.g., from base to apex) with a probability of 0.5. The simulated SFOAEs were obtained by simulating the pressure in the ear canal with and without roughness.

**INTRODUCTION**

Nonlinear Model: It has been demonstrated that an active one-dimensional transmission-line model of the cochlea can be used to account for connections between otoacoustic emissions, physiology, and psychophysics (Epp et al., 2010, JASA 128:1870-1883). The model consists of 1000 segments coupled to its neighbors via the fluid, each segment describing the mechanics of one place on the basilar membrane (BM) at longitudinal location z. The deflection d of the BM is described by a combination of a negative damping and a time-delayed feedback stiffness (Jääskeläinen et al., 2010, JASA).

\[
\dot{x} = m \ddot{x}(x, t) + d(x, t) \dot{x} + c(x, t) \ddot{x} + \xi(x, t).
\]

**METHODS**

**NONLINEAR MODEL**

**SUMMARY**

**NEXT STEPS**