Metabolic Presbyacusis: Longitudinal Changes in Hearing for Middle-Aged and Older Adults

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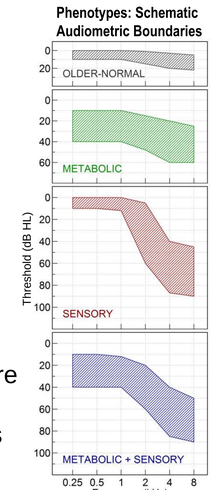
Introduction

Four distinct phenotypes of age-related hearing loss observed in animal models have been characterized in audiograms from older humans (Dubno et al., 2013; Schmiedt, 2010).

- **Older-Normal Hearing**.
- **Metabolic Presbyacusis** (related to cochlear lateral wall deterioration and reduced endocochlear potential).
- **Sensory Presbyacusis** (damage to sensory and non-sensory cells, loss of cochlear amplifier and nonlinearities).
- **Metabolic + Sensory** (combined effects of metabolic and sensory loss).



Demographic information (i.e., age, sex, noise exposure history) was used to validate the four phenotypes in cross-sectional audiogram data. Metabolic phenotypes were older, more likely to be female, and less likely to have a positive noise history (Dubno et al., 2013).

The current study used longitudinal audiogram data to determine if the likelihood of metabolic phenotypes increases with age.

Method

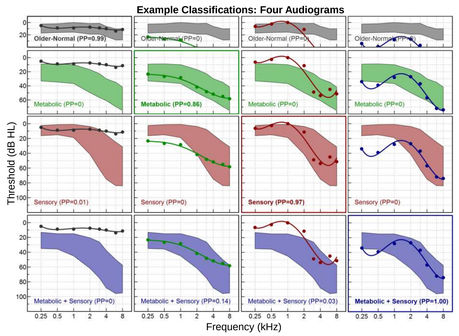
Audiograms. Audiograms were collected longitudinally from adults 50-90 years old (N=343; 1987-2015) and averaged by clusters of visits (3+ per year) to produce 1,826 mean audiograms (M=2.7 per ear).

Classification of audiograms. Quadratic Discriminant Analysis (QDA) was performed to classify audiograms, based on the similarity of each to 897 expert-labeled cases (*training data*; Dubno et al., 2013).

Phenotype distributions

Curve parameters (e.g., intercept, slope) for the shape of each audiogram were input to QDA.

Cross-validation tests showed optimal accuracy (80%) with five curve parameters.



Above: QDA posterior probability (PP) quantifies the similarity of an audiogram (points) to training data (shaded regions). Correct classifications typically result in higher PPs than incorrect ones.

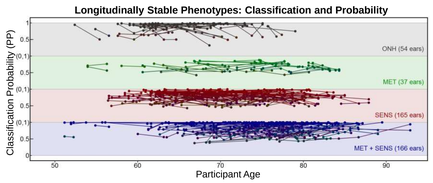
Post-Classification Analyses

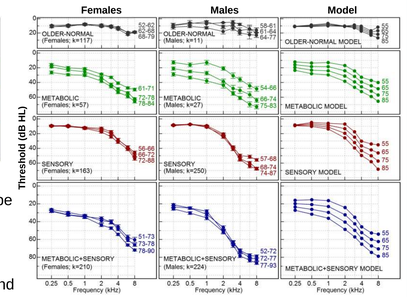
1) Demographic information (i.e. age, sex) and rates of threshold change were calculated for ears with stable and changing phenotypes.

2) Transitional probabilities for each phenotype changes were estimated based on phenotype classifications at the initial and final visit.

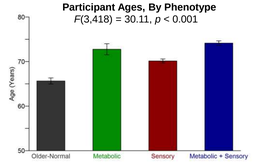
Results: Stable and Changing Phenotypes

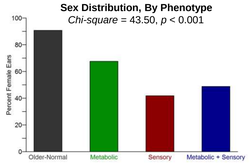
Stable phenotypes. Audiometric phenotypes did not change for most ears (62%), although thresholds increased with age (Echt et al., 2010; Lee et al., 2005). A majority of right/left ears (90%) had the same phenotype across all time points.

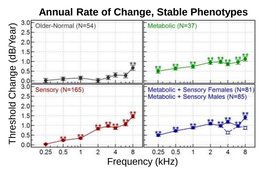




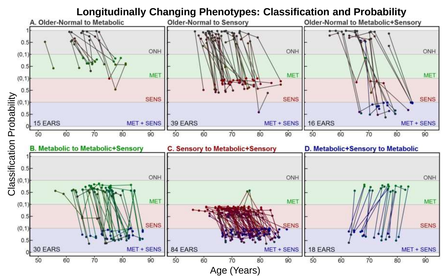
Above: Most ears (lines) remained within the same phenotype classification with increasing age (four shaded regions and abscissa), although probabilities varied (points). **Right:** Audiometric patterns consistent with each phenotype were preserved despite increasing thresholds. **Below:** Metabolic and Metabolic + Sensory cases were older than the others [$t(420) = 7.98$, $p < 0.001$]. Sensory cases were more likely to be male than the others [Chi-square = 13.07, $p < 0.001$].

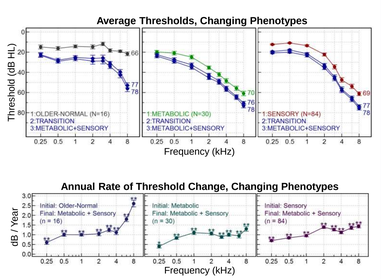




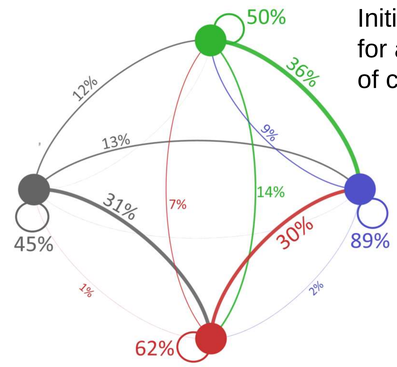


Changing phenotypes. Most of these cases transitioned to Metabolic (22%) or Metabolic + Sensory (54%). Sensory and Metabolic cases that transitioned to Metabolic + Sensory demonstrated patterns of threshold change that were similar to stable Metabolic cases.





Results: Transitional Probabilities



Initial and final phenotypes were counted for all 686 ears to calculate the likelihood of changing to another phenotype.

Older-Normal ears were the most likely to change (55%).

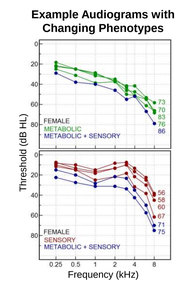
Metabolic + Sensory ears were the least likely to change (11%).

Above: The likelihood of phenotype change or no change. Filled circles depict the phenotype classification at the initial visit, and same-colored lines depict possible phenotype changes by the final visit (e.g., 30% chance that Sensory cases become Metabolic + Sensory). Open circles depict cases with a stable phenotype. Probabilities sum to 100% for each initial phenotype.

Conclusions

Analysis of audiograms obtained longitudinally from middle-aged and older adults further validated classifications of phenotypes of age-related hearing loss.

A majority of ears showed stable phenotypes over time, even while hearing loss was increasing. The stable Metabolic and Metabolic + Sensory cases were older, on average, than other phenotype cases.



The remainder showed changes in phenotypes with increasing age, with the most common change to metabolic phenotypes.

These results are consistent with the conclusion that the likelihood of metabolic phenotypes increases with age in older adulthood.

References

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