Evidence for age-related cochlear synaptopathy unconnected to auditory temporal processing deficits

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Motivation

Cochlear synaptopathy [1] may degrade the neural coding of temporal sound features, hence underlie age-related temporal processing deficits. We investigated the potential contribution from synaptopathy and cochlear deficits to age-related deficits in temporal integration, gap detection [2], and frequency-modulation detection [3, 9].

Hypotheses

1. Synaptopathy hinders brief-tone detection, hence steepens threshold-duration function slope (TDS) [4].
2. Synaptopathy increases gap-detection thresholds (GDTs) and frequency-modulation detection thresholds (FMDTs).

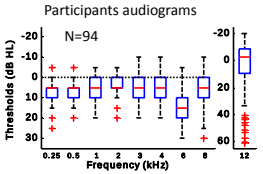
Synaptopathy metric

Based on findings in rodents [1, 5], we assumed that synaptopathy reduces the rate of growth of ABR wave-I amplitude with increasing stimulus intensity.

Methods

Participants

- N=61/66/45 (TDS/GDT/FMDT)
- 24-68 yr. (median = 25 yr.)



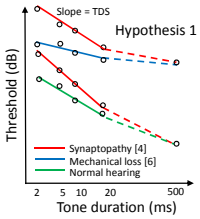
Absolute thresholds

- Pure tones.
- 1-ms onset/offset ramps.

kHz	Duration (ms)
0.5	5, 10, 20, 500
1.5	2, 5, 10, 20, 500
4.0	2, 5, 10, 20, 500
8.0	2, 5, 10, 20, 500
12.0	5, 500

Analysis. TDS

Straight lines were fitted to tone thresholds (2-20 ms) and slopes adjusted for audiometric loss (long-tone thresholds).



ABR recording

- ER-3A insert phones.
- Rarefaction clicks.
- 90:5:110 ppe dB SPL
- Rate: 11 clicks/sec.
- Filtering: 0.1-3 kHz.
- 2048 to 8192 sweeps.

Noise exposure

Questionnaire estimating number of years of acceptable yearly exposure (AYE = 8 h at 85 dBA over 220 days) [7].

Frequency modulation detection

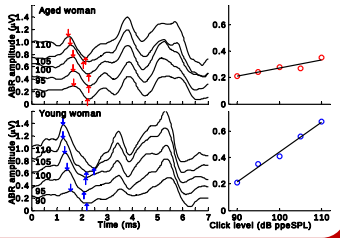
- Pure tone carrier, 1.5 kHz
- 30 & 60 dB SL
- 2 Hz modulation rate

Gap detection

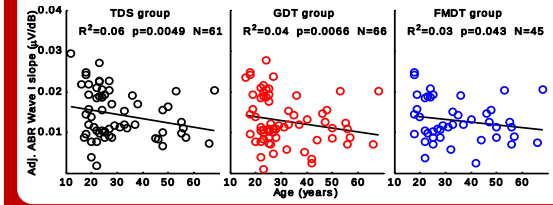
- Pure tone markers (2 kHz).
- Durations 5 & 50 ms, 1-ms ramps
- 80 dB SPL
- ER-2 insert phones.
- 3AFC, one-up, two-down [8].

Analysis. ABR

Straight lines were fitted to wave I amplitude-level function and slopes (in µV/dB) adjusted for high-frequency thresholds.



Results. Evidence for age-related but not noise related synaptopathy

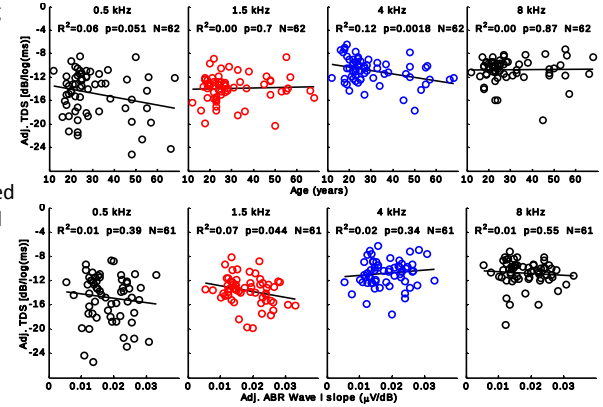


Wave I slope was shallower with increasing age, but was not correlated with noise exposure (not shown).

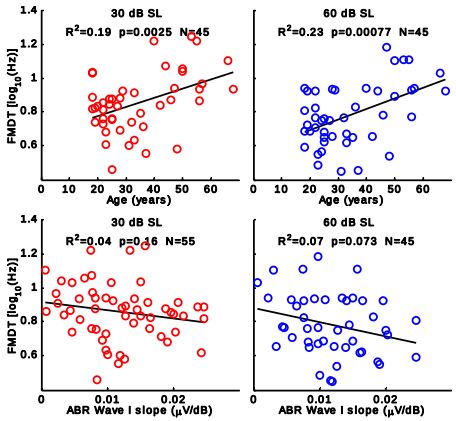
Results. Temporal integration

After accounting for audiometric loss, age did not affect brief-tone detection.

No correlation between adjusted wave I slope and adjusted TDSs. Hence synaptopathy is unlikely to affect brief-tone detection.



Results. Frequency modulation detection



FMDTs increased with increasing age, consistent with earlier studies [9].

But FMDTs were not correlated with wave I slope, suggesting that age-related frequency-modulation detection deficits are not due to synaptopathy.

Acknowledgements

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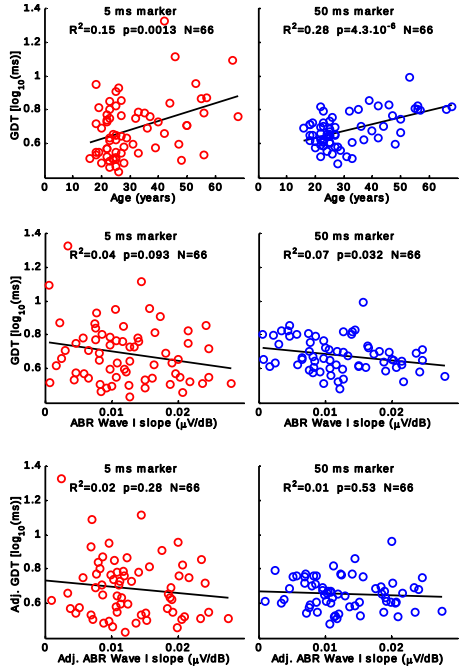
Results. Gap detection



GDTs increased with increasing age, consistent with previous studies [2].

Longer GDTs were associated with shallower ABR wave I slopes, suggesting that synaptopathy might contribute to age-related deficits in gap detection.

However, after accounting for the effects of audiometric threshold on wave I slope and GDTs, slope was not correlated with GDT. Therefore, synaptopathy is unlikely to contribute to age-related deficits in gap detection.

Results. Noise exposure

Lifetime noise exposure was not correlated with TDSs, FMDTs or GDTs.

Discussion

- Adjusted TDSs were not larger with increasing age nor were they correlated with threshold-adjusted ABR wave I slope.
- FMDTs were larger with increasing age but were not correlated with ABR slope.
- GDTs were longer with increasing age and shallower ABR slope but not after accounting for the effects of thresholds.

Key findings

1. Frequency-modulation detection and gap detection (but not brief-tone detection) were poorer with increasing age.
2. These age-related temporal processing deficits were somewhat correlated with audiometric losses, but not with threshold-adjusted ABR wave I slope.
3. Hence, synaptopathy unlikely contributed to those deficits.

References

[1] Kujawa & Liberman, 2009, J. Neurosci. 29:14077:14085.
[2] Schneider & Hamstra, 1999, JASA, 106:371:380.
[3] Moore & Sek, 1996, JASA:100:2320:2331.
[4] Marmel et al., 2014, Front. Aging Neurosci. 7:63
[5] Furman et al., 2013, J. Neurophysiol. 110:577-586.
[6] Florentine et al., 1988, JASA 84:195–203.
[7] Beach et al., 2013, Int. J. Audiol, 52: S20-S25.
[8] Levitt, 1971, JASA 49:466-477.
[9] He et al., 2007, JASA, 122:467-477