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Can the acoustic reflex be used as a quantitative research tool?

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Background

- The acoustic reflex (AR) is a well-known clinical tool in which the threshold is established via present/absent determinations.
- Recently there has been much interest in the research community in using the AR as a quantitative research tool.
- The AR has been shown in animals to be reduced as a result of cochlear synaptopathy [1]. It is also reduced in human listeners with tinnitus [2].
- It is suggested that the AR may be able to detect sub-clinical changes to the auditory system, such as a loss of cochlear synapses due to noise exposure [3].
- Many of these recent studies use wideband reflectance systems, in which the probe sound is a click rather than a 226 Hz tone.

Aims

- To determine if AR threshold and growth, measured using the clinical 226 Hz probe tone, vary with lifetime noise exposure.
- Identify which factors need to be considered (i.e. sex, peak middle-ear compliance, age, audiometric profile) when using the AR as a quantitative investigative tool.

Methods

Participants

45 adults aged 18-40 (30 female) were tested. All participants had pure tone hearing thresholds of 20 dB HL or better in the range 0.25-8 kHz.

Noise Exposure

Lifetime noise exposure was estimated via structured interview [4]. The approach seeks to identify the frequency with which high sound-intensity environments (>85 dBA) are visited. Common recreational activities (nightclubs/live music/listening to personal music devices) dominate the entries.

The output is an estimate of overall energy exposure.

Acoustic Reflex Parameters

ARs were measured from the right ear using a GSI TympstarPro middle ear analyser using a 226 Hz probe tone (trains of 40 ms pulses).

ARs were measured in response to three elicitors; pure tones at 0.5 and 2 kHz and a 0.4-4 kHz broadband noise (BBN).

Elicitors were presented both ipsilaterally and contralaterally, producing 6 experimental conditions.

For each condition, a "run" was conducted as follows;

- Threshold was established, as the lowest stimulus level resulting in a middle-ear compliance change greater than 0.02 ml.
- Three further measurements were then made at 5-, 10 and 15 dB above threshold to quantify growth.
- 3 consecutive runs were performed for a given condition before moving on to the next.

Analysis

For each condition, a linear regression was performed for each of the 3 runs and these functions were then averaged.

The regression function was used to estimate the sound intensity which produced a change in tympanometric compliance of 0.02 ml.

The slope of the regression function was used to calculate AR growth, represented as the rate of change in compliance for each 5 dB in stimulus level (cm^3/5dB)

Results

Fig 1. shows the grand average AR thresholds and growth for each of the 6 conditions.

Ipsilateral estimates of AR growth are larger than contralateral growth. AR thresholds are lower for ipsilateral measures, with BBN yielding lower thresholds than the two tonal elicitors. These patterns are consistent with the literature.

The response rate for each condition is shown below;

- Contralateral
  0.5 kHz = 80%
  2 kHz = 98%
  BBN = 100%
- Ipsilateral
  0.5 kHz = 73%
  2 kHz = 91%
  BBN = 91%

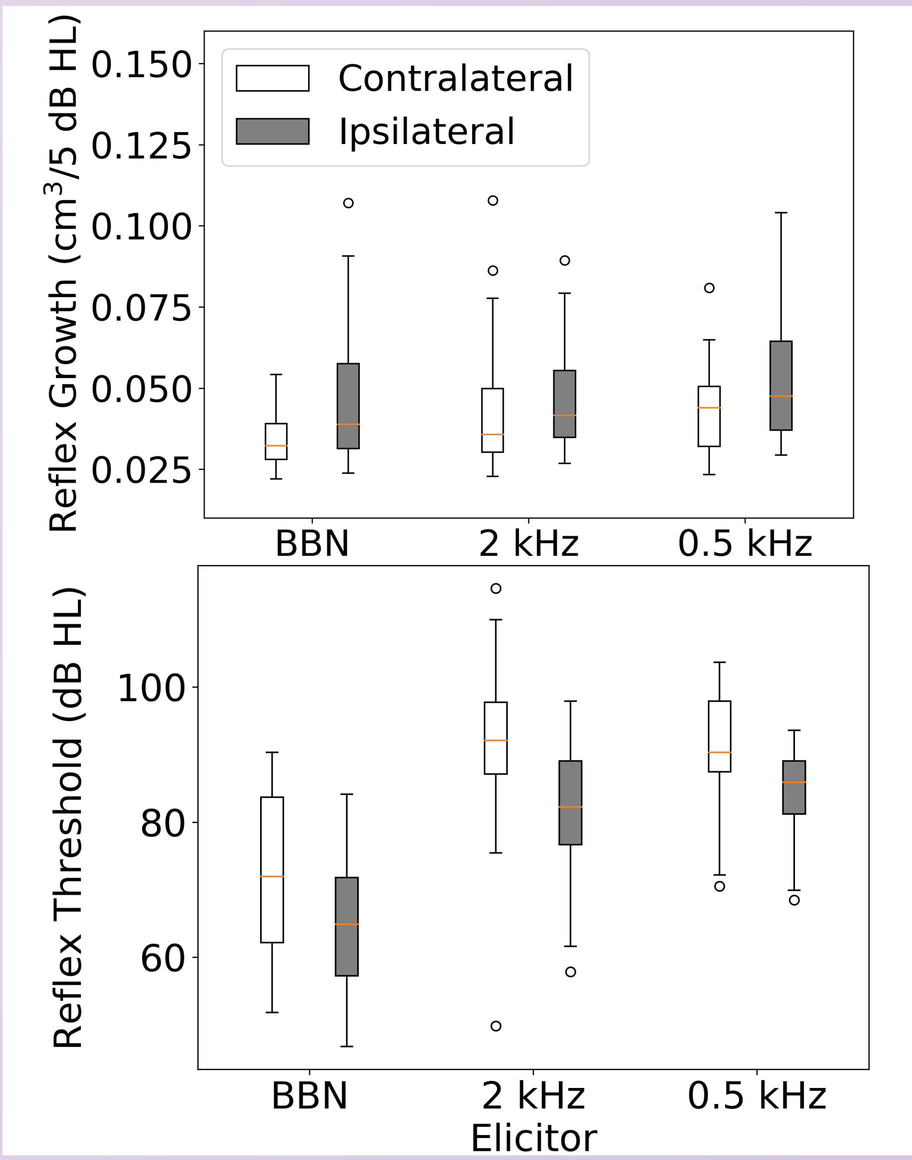

Fig 1. (above) Upper panel shows boxplots of AR growth across the 6 conditions. Lower panel shows thresholds.

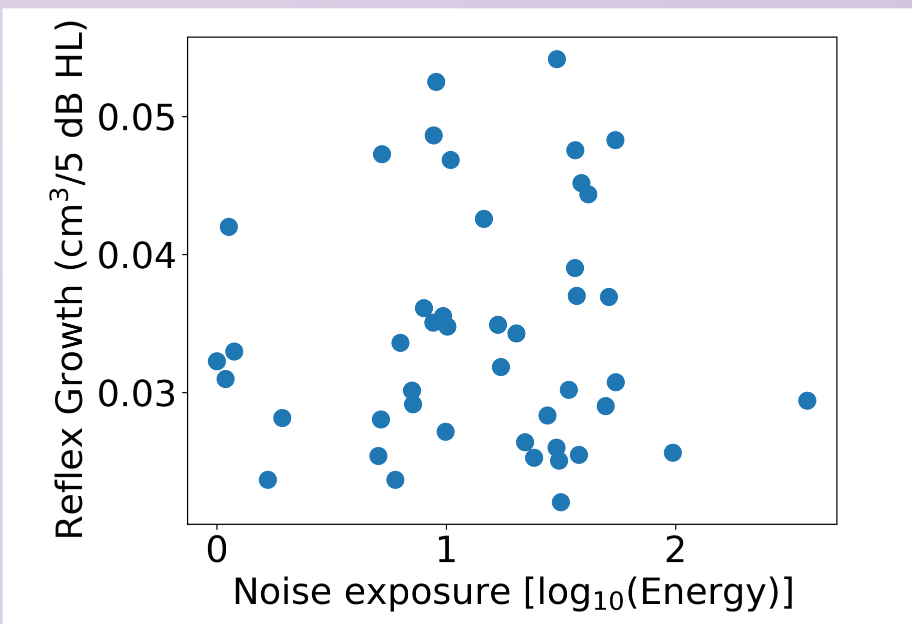

Fig 2. A scatter plot of reflex growth as a function of lifetime noise exposure is shown for the contralateral BBN elicitor.

Correlations

- There was no relation between lifetime noise exposure and AR threshold (r=0.009, p=0.95), nor AR growth (r=0.074, p=0.62, shown in Fig. 2) for the contralateral BBN elicitor.
- Measures of threshold and growth, elicited by a contralateral BBN showed no relation to each other (r=-0.24, p=0.12).
- As shown for contralateral BBN in Fig 2. peak middle-ear compliance (the peak of the recorded tympanogram) was correlated with AR growth (r=0.45, p<0.01). This pattern was replicated across the other 5 conditions for AR growth.
- For a contralateral BBN elicitor there was no relation between AR thresholds and sex (t=-1.92, p=0.06). However males showed steeper growth functions (t=2.3, p=0.028).
- Males also showed greater levels of middle-ear compliance than females (t=2.56, p=0.017).

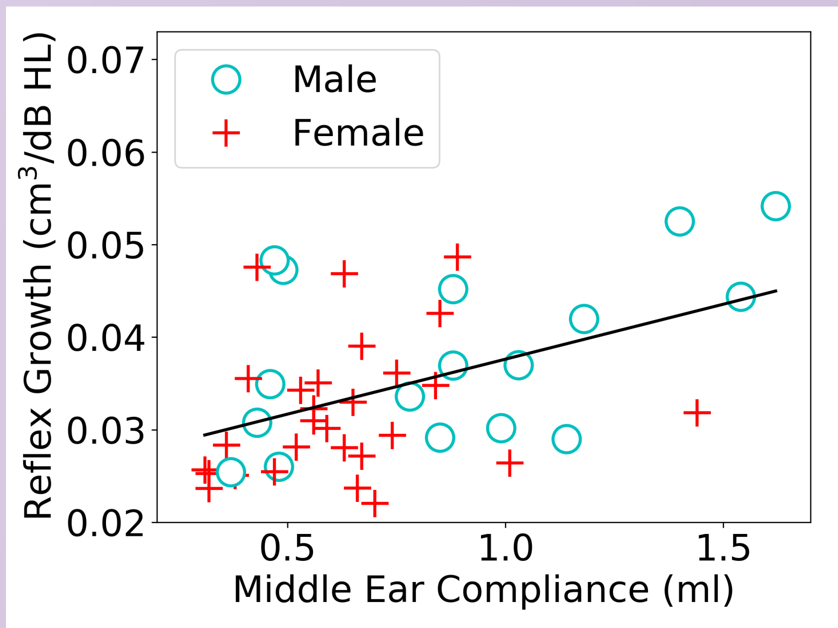

Fig 3. Reflex growth is shown as a function of peak middle-ear compliance for a contralateral BBN elicitor. Male and female listeners are differentiated by colour and symbol.

Summary

In listeners with normal hearing, there is no evidence that AR threshold or growth varies with lifetime noise exposure.

The different elicitors, sides-of-stimulation, and summary metrics (threshold or growth) only weakly relate to each other. In a single cohort of listeners their relative AR strength will change depending on the specific parameters chosen. This is problematic.

The degree of middle-ear compliance observed is predicted by sex.

Listeners with high levels of middle-ear compliance exhibit steeper growth functions.

The relation between sex, middle-ear compliance, AR threshold and growth is unclear. There currently appear to be too many factors which affect the AR for it to be used as a quantitative diagnostic tool.

References

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[2] Wojtczak et al. (2017). eNeuro. 4: 0363-17.2017
[3] Bharadwaj et al. (2019). Neurosci. 407: 53-66.
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Acknowledgments

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