00543 The association between occupational noise exposure and speech perception in young adults

NOISE EXPOSURE

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INTRODUCTION

Some people with normal audiograms report difficulty understanding speech in noisy environments, a condition known as **hidden hearing loss** (1).

This may be caused by the vulnerability of synapses in inner hair cells and type I fibers with low spontaneous firing rates. The loss of these synapses, known as **cochlear synaptopathy**, affects speech encoding in noisy settings (2, 3, 4). While this theory is supported by animal studies, evidence in humans is limited. **There are currently no diagnostic tools for cochlear synaptopathy** (5, 6).

Research has suggested that the **Frequency Following Response (FFR)** could detect this condition, as noise exposure reduces FFR amplitude in mice (4).

Aim: The aim of this study is to investigate a possible association between occupational noise exposure and poorer encoding of speech sounds at the brainstem level in young adults with normal hearing thresholds.

MATERIALS & METHODS

Sample: 44 male participants not older than 40 years, exposed to occupational noise (≥85dB A) and 44 male participants without noise exposure (≥80 dB A) from Zhejiang province, China were included. All participants presented with Type A tympanogram, normal hearing thresholds (≤20 dB HL from 0.25 to 8 kHz), and presence of DPOAEs (amplitude > -20 dB SPL and SNR > 3dB) in the right ear.

Pure-tone audiometry: Hearing thresholds at 0.25, 0.5, 1, 2, 3, 4, 6, 8, 9, 10, 11.2, 12, and 14 kHz were obtained, bilaterally. PTA_4: average of 0.5, 1, 2, 4 kHz and PTA_{HF}: average of 9 to 14 kHz were calculated for analyses purposes.

DPOAEs: Two primaries (L1, L2) were used with f2 at 1 ,2 ,3 ,4 ,5 ,6 ,7 ,8 ,9 , and 10 kHz, with 65/55 dB SPL (L1/L2) and 1.22 ratio (f1/f2). Measured noise floor, amplitude, and SNR were obtained. $DPOEA_{mean}$: average SNR of all frequencies was calculated for analyses.

Mandarin Bamford-Kowal-Bench sentence test (Mandarin BKB): Speech recognition in noise was tested in the right ear. An SNR-50% was obtained for each participant.

Complex-auditory brainstem response (cABR): Surface electrodes placed at Fz (positive), Fpz (ground) and on the mastoid (M2) were used for all recordings. cABR was elicited by a 40-ms synthesized /da/ syllable provided by the IHS SmartEP module at 80 dB SPL in alternating polarity at a rate of 10.9/sec. A grand average from 6000 sweeps was obtained for the right ear. cABR peaks were manually marked and then corrected with the MATLAB-based Brainstem toolbox (8). The FFR recordings were off-line filtered with a 70-2000 Hz bandpass and then analyzed with the Brainstem toolbox. The spectral encoding was analyzed using Fast Fourier Transform (FFT) Fundamental frequency (F_0)103-120 ; first formant (F_1) 455-720; higher frequency formant (F_{HF}) 721-1154 Hz). The root mean square (RMS) amplitude of the FFR was calculated to obtained the SNR. Finally, the stimulus-to-response (SR) correlation was used to obtain the Pearson's correlation coefficient r (SR corr) and the temporal delay when the signal is maximally correlated with the response (SR Lag).

Statistical analysis: Group comparisons were conducted using a Mann-Whitney test for age, BKB score, and FFR SNR. Group comparisons were conducted using a two-way ANOVA with repeated measures followed by a post hoc Student t-test with Bonferroni correction for audiometric thresholds, DPOAE SNR, cABR peak latency, FFT results, and SR results. A correlation matrix was performed including age, BKB, F0 amplitude, PTA_4, PTA_{HF}, $DPOEA_{mean}$, FFR SNR, SR corr, SR Lag, and cABR peak C latency. Finally, a multivariable regression model was constructed with the aim to investigate the association between group category (exposed versus non-exposed) and peak-C latency controlling for covariates.

RESULTS

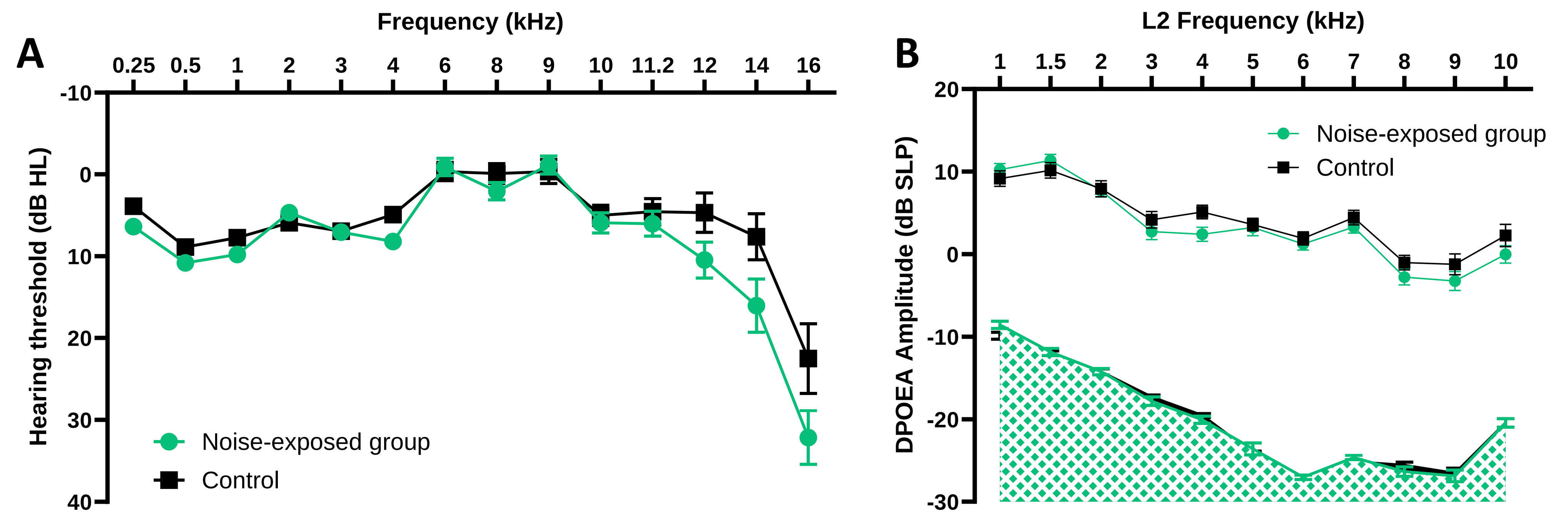

Figure 1. (A) Pure-tone audiometric thresholds in dB HL at the right ear from 0.25 to 16 kHz in the noise-exposed (green) and control group (black). **(B)** DPOEA amplitudes (line) and noise-floor (area fill) in dB SPL at the right ear for L2 frequency from 1 to 10 kHz in the noise-exposed (green) and control group (black). Error bars represent the standard error. No significant differences between groups are observed.

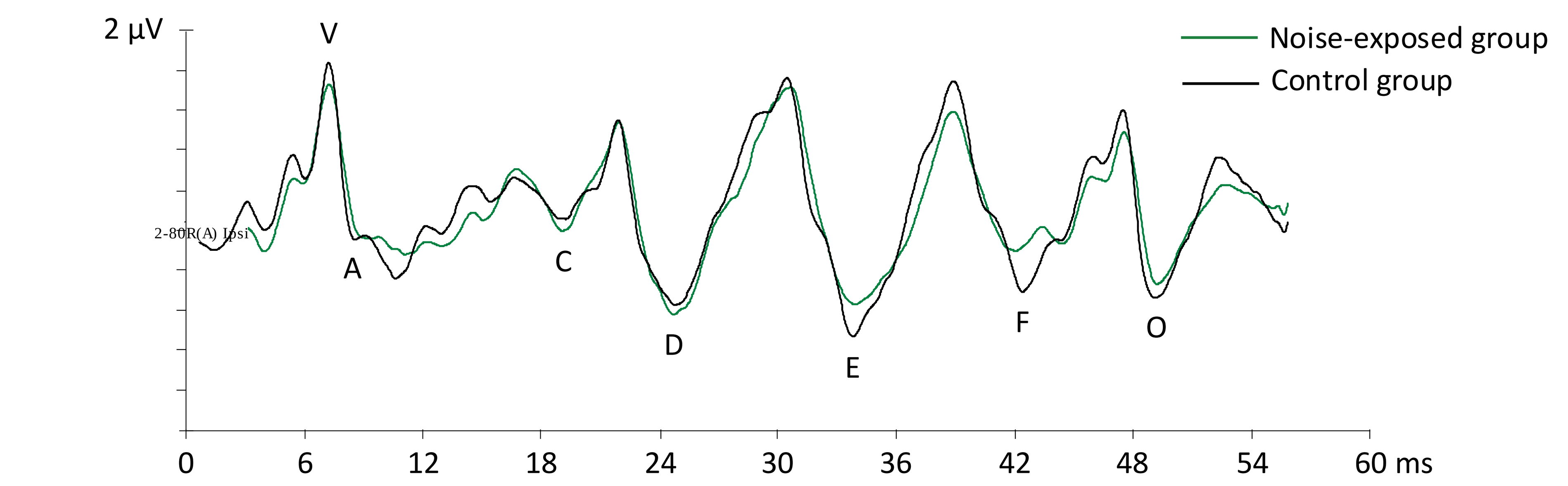

Figure 2. Grand average cABR triggered by 40 ms /da/ stimulus at 80 dB nHL for the noise-exposed (green) and control group (black). Wave V, A, C, D, E, F and O are labelled.

A.	BKB	PTA_4	PTA_{HF}	Amp F0	$DPOEA_{mean}$	SNR	SR corr	SR Lag	Age	C Latency	CNE
BKB	.	0.270	-0.082	0.157	-0.006	0.021	0.234	-0.049	0.014	-0.019	**0.528 *** **
PTA_4	.	.	0.090	0.286	-0.252	0.013	-0.129	-0.157	-0.036	**-0.318 ***	0.239
PTA_{HF}	.	.	.	0.127	-0.092	0.142	-0.191	0.009	0.106	0.044	-0.028
Amp F0	.	.	.	.	-0.169	**0.392 ****	-0.225	-0.007	-0.074	**-0.480 *****	-0.121
$DPOEA_{mean}$	.	.	.	.	.	0.112	**-0.342 ***	0.000	-0.171	0.057	-0.024
SNR	.	.	.	.	.	.	-0.091	-0.063	-0.006	0.004	-0.020
SR corr	.	.	.	.	.	.	.	0.056	**0.310 ***	0.183	0.024
SR Lag	.	.	.	.	.	.	.	.	-0.109	0.119	0.006
Age	.	.	.	.	.	.	.	.	.	0.099	0.035
C Latency	.	.	.	.	.	.	.	.	.	.	0.143
CNE	.	.	.	.	.	.	.	.	.	.	.

B.	BKB	PTA_4	PTA_{HF}	Amp F0	$DPOEA_{mean}$	SNR	SR corr	SR Lag	Age	C Latency
BKB	.	0.044	0.030	0.226	0.100	0.164	-0.100	0.016	**-0.541 *****	0.303
PTA_4	.	.	**0.380 ***	0.181	-0.070	0.005	0.021	-0.045	0.373	0.068
PTA_{HF}	.	.	.	0.077	**-0.434 ****	0.107	**0.372 ***	-0.095	0.263	0.009
Amp F0	.	.	.	.	-0.161	**0.747 *******	0.101	0.213	-0.034	0.045
$DPOEA_{mean}$	.	.	.	.	.	-0.049	-0.230	-0.035	-0.198	0.031
SNR	.	.	.	.	.	.	0.190	-0.092	-0.050	0.009
SR corr	.	.	.	.	.	.	.	-0.284	0.184	0.209
SR Lag	.	.	.	.	.	.	.	.	0.216	**-0.397 ***
Age	.	.	.	.	.	.	.	.	.	**-0.531 *****
C Latency	.	.	.	.	.	.	.	.	.	.

Table 1. (A) Correlation coefficients (Spearman) between BKB, PTA_4, PTA_{HF}, Amp F0, $DPOEA_{mean}$, measures of the FFR, age, C peak latency and cumulative noise exposure (CNE) for the noise-exposed group. **(B)** Correlation coefficients (Spearman) between BKB, PTA_4, PTA_{HF}, Amp F0, $DPOEA_{mean}$, measures of the FFR, age and C peak latency for the control group.* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$

	Noise-exposed group				Control				
	Mean	±	SD	(n)	Mean	±	SD	(n)	P-value
A. Age and auditory outcomes									
Age	27.14	±	04.03	(44)	23.39	±	5.13	(44)	**<0.0001 *******
PTA_4	8.35	±	3.59	(44)	6.85	±	3.39	(44)	0.744
PTA_{HF}	7.46	±	9.46	(44)	4.30	±	10.07	(44)	>0.999
BKB score	0.14	±	3.59	(44)	0.28	±	3.03	(44)	0.584
B. C-ABR Latency (ms)									
Peak V	7.44	±	0.45	(43)	7.35	±	0.28	(39)	>0.999
Peak A	8.92	±	0.91	(43)	8.55	±	0.46	(39)	0.170
Peak C	18.96	±	0.82	(42)	18.15	±	1.54	(39)	**0.036 ***
Peak D	23.98	±	0.98	(43)	23.85	±	1.17	(41)	>0.999
Peak E	33.43	±	1.21	(43)	33.23	±	1.54	(42)	>0.999
Peak F	41.89	±	1.47	(43)	42.32	±	1.45	(42)	>0.999
Peak O	49.21	±	0.60	(43)	48.95	±	0.78	(42)	0.588
C. FFR Spectral analyse (µV)									
SNR	3.411	±	2.38	(44)	4.192	±	3.24	(42)	0.237
F_0	123.93	±	186.572	(44)	189.10	±	325.41	(42)	0.810
F_2	8.61	±	3.984	(44)	09.07	±	5.50	(42)	>0.999
F_{HF}	2.45	±	0.747	(44)	2.54	±	0.79	(42)	>0.999
D. Stimulus-to-response (SR) correlation									
SR corr. (r)	0.14	±	0.04	(44)	0.13	±	0.05	(42)	>0.999
SR Lag (ms)	7.18	±	0.80	(44)	7.45	±	01.02	(42)	0.124

Table 2. Mean, standard deviation (SD) and group comparisons for: **(A)** age and auditory outcomes such as PTA_4, PTA_{HF} and BKB score; **(B)** cABR latency for waves V, A, C, D, E, F and O; **(C)** FFR spectral magnitude measures including SNR, amplitudes of the fundamental frequency (F_0), first formant (F_1) and higher frequency formant (F_{HF})in µV; **(D)** SR correlation of the FFR, Pearson's r of the maximum SR correlation and SR Lag of the correlation in ms. * $p < 0.05$; **** $p < 0,0001$.

MAIN RESULTS

- A positive correlation between BKB scores and measures of occupational noise exposure in the noise-exposed group.
- In the noise-exposed group, c-wave latency was significantly longer than in the control group. However, the proposed multivariable linear regression model did not explain the variations in C-wave latency

DISCUSSION & CONCLUSION

- In this study, we observed a significant increase in C-peak latency in the noise-exposed group. In a previous study, the increase in C-peak latency was observed when the stimulus was presented along with background noise (9).
- For participants in the noise-exposed group, the greater the exposure to occupational noise, the greater the difficulty in understanding speech in noise.
- We evaluated native Mandarin speakers using the syllable /da/, rather than a characteristic stimulus of the language. Previous studies have shown that language experience (native vs. non-native speakers) influences sound encoding strength, which may explain the minimal differences observed in FFR between both groups (10).
- A study indicated that the BKB is less sensitive to the recognition of speech in background noise than tests like WIN and QuickSIN. However, such tests are limited in Mandarin (11).
- Important to note is that we may have introduced a selection bias by including only participants with normal hearing thresholds and otoacoustic emissions at all frequencies despite their noise exposure history. We probably selected people with "tough" ears, who might not have presented evident signs of cochlear synaptopathy (12).
- Based on these results, we cannot conclude that the FFR is an effective diagnostic tool for detecting cochlear synaptopathy in humans.

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