
Nikki A. Go & Tiffany A. Johnson
Department of Hearing and Speech, University of Kansas Medical Center, Kansas City, Kansas

INTRODUCTION

Background: Difficulty understanding speech in noise (SIN) is a common complaint among many listeners. There is emerging evidence that noise exposure is associated with difficulties in speech discrimination and temporal processing despite normal audiometric thresholds. Recent data from animal studies have revealed significant deafferentation of select auditory nerve fibers after full recovery of threshold responses following noise exposure (Kujawa & Liberman, 2006, 2009). While there is some evidence suggesting noise-induced synaptopathy in human ears (e.g., Stamper & Johnson, 2015), the perceptual consequences of this phenomenon remain unclear.

Research Objective: This study explores the link between recreational noise exposure, evoked potential estimates of neural survival and temporal processing, and perceptual deficits in humans with normal thresholds.

METHODS

Subjects: Data were collected from 30 normal-hearing subjects (18-35 years old). All subjects had hearing thresholds ≤ 20 dB HL (Re: ANSI S3.6-2004) for frequencies 250-8000 Hz and normal middle ear and outer hair cell function.

Equipment: Auditory Brainstem Response (ABR) testing was performed using the TDT System 3 (Tucker-Davis Technologies, Inc.). Acoustic stimuli were created using TDT software SigGenRP and were presented via E-A-R-Tone 3A insert earphones. BioSigRP was used to record and analyze ABR waveforms.

Procedures: Noise Exposure Questionnaire (NEQ): Noise-exposure background was assessed via a noise exposure questionnaire (Johnson et al., 2017) that calculated the number of hours spent annually in specific high-noise environments (occupational, music listening, power tools, etc.). The NEQ yields a value that is an estimate of the annual amount of noise exposure in Leq, as shown in Figure 1. A histogram of the NEQ values obtained across all 30 subjects. The NEQ has a theoretical range of 64 to 95.5 Leq yr/dec. The subjects tested here ranged from 64 to 86.9 Leq yr/dec. This demonstrates that the NEQ values in the present study span a wide range and indicates variation in noise exposure background across subjects. Additional recruitment efforts focused on having equal distribution of males and females across all subjects.

Auditory Evoked Potentials: ABRs were recorded to both a click (as a measure of neural survival) and speech stimulus /da/ (as a measure of temporal processing). The following stimulus and recording parameters were used:

- Stimulus Duration: 100 μsec
- Stimulus Intensity: 40 ms
- Presentation Mode: Monaural
- Stimulus Level: 85 dB SPL
- Bandpass Filter: 100 - 3000 Hz
- Waveform: 3000 (5 waves)
- Electrode Montage: (c) forehead, (i) vertex, (j) mastoid, (k) suprasternal, (l) suprasternal, (m) ground, (n) contralateral/mastoid, (o) contralateral earlobe.

Speech, Spatial, and Qualities of Hearing Scale (SSQ): The SSQ v 5.6; Gates & Noble, 2004) was administered to all individual self-reported SIN abilities. It was designed to measure a range of hearing disabilities across several domains (i.e. speech hearing, spatial hearing, segregation of sound, recognition, clarity/naturalness, and listening effort). The questions inquire about an individual’s ability and experience hearing and listening in different situations. For each question, subjects were asked to indicate the amount of difficulty experienced in each environment on a scale of 0 through 10, with higher scores reflecting less difficulty. An average score for the speech-hearing and spatial-hearing subscale was calculated for each subject which reflects individual self-perception of ability.

Analyses: Linear regression analysis was used to explore and describe the relationships between auditory response behavior, self-reported SIN perception, and noise exposure background.

RESULTS

Figure 2 shows the SSQ-Speech Hearing subscale score (top row) and SSQ-Spatial Hearing subscale score as a function of annual noise exposure (NEQ value). A statistically significant relationship was revealed between self-reported speech-in-noise ability and noise exposure background. Individuals with greater noise exposure reported experiencing greater difficulty hearing speech in the presence of background noise. Additionally, a statistically significant relationship was also seen between spatial hearing ability and noise exposure background. Those individuals with greater noise exposure had subjective ratings of poorer sound localization ability. No significant relationship was revealed between any of the SSQ subscales and click- and speech-ABR responses. Note: * ≤ 0.05

Figure 3 shows the ABR wave I (top row) and wave V (bottom row) amplitudes as a function of annual noise exposure (NEQ value) for click stimulus at 80 dB HL. No statistically significant relationship were revealed between ABR wave I amplitude and noise exposure background. Likewise, no significant relationship was seen between wave V amplitude and noise exposure background. This lack of relationship was also observed with the latencies of waves I and V. Contrary to data from animal studies, the ABR wave I results provided no evidence for noise-induced synaptopathy in this group of subjects.

CONCLUSIONS

The present data resulted in mixed findings: 1) the click-ABR results consistent with noise-induced cochlear synaptopathy were not replicated in this group of young, normal-hearing adults; 2) significant decreases in the speech- and spatial-hearing subscales of the SSQ at annual noise exposure (ANE) increased was found; 3) speech-ABR data revealed no evidence of expected neural slowing with increased ANE and an unexpected increase in amplitude as ANE increased. This later finding could possibly be a manifestation of the influence of musical training — although this did not translate into decreased hearing difficulty in noise (on the SSQ), as had been reported by Parbery-Clark et al. (2009).

REFERENCES & ACKNOWLEDGEMENTS


Supported by AAA Foundation Student Investigator Research Grant