

## MRI Acoustic Noise Can Harm Research and Companion Animals

A. M. Lauer<sup>1</sup>, A. M. El-Sharkawy<sup>2</sup>, D. L. Kraitchman<sup>2</sup>, and W. A. Edelstein<sup>2</sup>

<sup>1</sup>Otolaryngology-HNS, Johns Hopkins School of Medicine, Baltimore, MD, United States, <sup>2</sup>Radiology/MRI Division, Johns Hopkins School of Medicine, Baltimore, MD, United States

**Introduction.** MRI scanner noise can cause discomfort and potential damage to human hearing. MRI is used extensively in animal research and, increasingly, as a diagnostic tool in veterinary medicine (e.g. [1]), generally with no hearing protection. Little if any consideration has been given to the effect of MRI scanner noise on animals. As with human subjects, however, loud sounds can cause temporary or permanent hearing loss and stress.

Effects of noise could be detrimental for research animals that will be used after scanning, or for companion animals that will be returned to owners. Noise-induced hearing loss can impede functions that involve the auditory system, such as the ability to hear vocal communication signals and the ability to localize sound sources. Exposure of young animals, even to moderate levels of noise, can result in accelerated hearing loss later in life. Though safe exposure standards have not been determined for most animals, it is important to consider that animals exposed to scanner noise may suffer hearing damage.

To study potential animal MRI adverse hearing effects, we measured sound levels produced by several animal scanning protocols in a commercial 3T scanner. Using hearing threshold data for research or companion animals, we estimate weighted sound pressure levels and compare these to levels at which damage occurs in humans.

**Methods and results.** We used a Larson-Davis LxT digital sound level meter to measure sound levels and spectra during MRI scans used for animal research imaging in a 3T clinical human scanner. Overall peak sound levels and third octave band levels were downloaded to a computer and analyzed offline.

Figure 1 shows a typical unweighted noise spectrum (represented as sound pressure levels (SPLs) for a range of 1/3 octave frequency bands), in this case for a survey pulse sequence (PS) used in an animal scan protocol.

Hearing threshold curves in Figure 2 have been obtained by fitting smooth curves to threshold data for human and animal subjects [2].

We calculated an estimated weighted SPL for each species by taking the difference between the measured SPL and the threshold curves. For humans, this approximates applying A-weighting, and the estimated weighted spectra derived from the human subject data in [2] agrees well with the calculated A-weighted result.

Table 1 shows the average weighted SPL for human and animal subjects vs. a sample list of pulse sequences used in cardiac protocols. Such scan protocols often last from 45-60 minutes.

**Discussion and conclusions.** SPLs for human subjects and all animals were above 90 dB on many scans and exceeded 100 dB for at least one scan, except for the Norway rat. However, the SPL for this animal as well as all others was above 90 dB for the interactive real-time pulse sequence

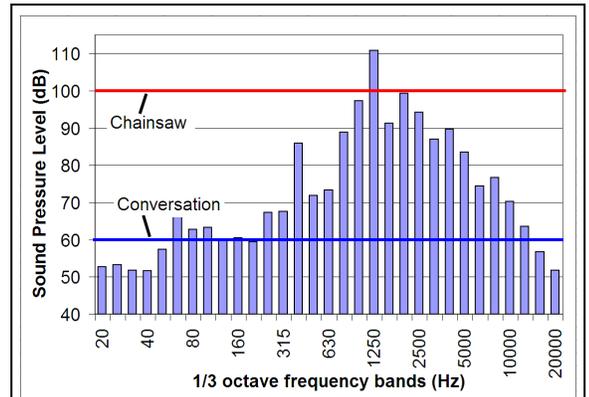
The most sensitive animal subject was the cat and the least, the pig. The Norway rat's hearing range is shifted to high frequencies relative to the MR noise spectra peak, thus reducing the rat's weighted SPL.

The dog threshold was averaged from four individual dogs, one of which had a 10 dB lower threshold than the average. This would be reflected in higher weighted SPLs for that individual, which might suffer more damage.

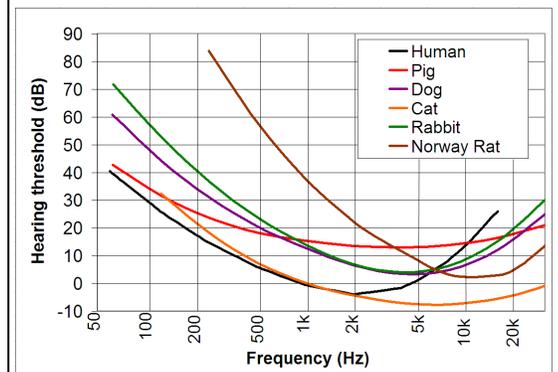
The US National Institute for Occupational Safety and Health (NIOSH) has recommended exposure limits for noise levels in order to avoid induced hearing loss [3]. Similar effects are likely to occur in animals.

NIOSH standards say that exposure time should not exceed 30, 15 and 1 min for sound levels of 90, 100 and 110 dB respectively. Clearly all animal species listed in this study may exceed some of these standards. Thus it is important to use hearing protection, quieter pulse sequences or quieter scanners for animal research MRI or animal veterinary MRI.

**Refs:** 1) 2009 VetMRI NJ, <http://www.vetmri.com/> 2) Heffner H 2004 <http://tinyurl.com/y8afc24>  
3) NIOSH 98-126 1998 <http://www.cdc.gov/niosh/docs/98-126/>



**Figure 1.** Audio spectrum from multi-slice 2D Field Echo (FE) sequence used in a survey scan. The spectrum has a broad maximum between about 800 and 3000 Hz.



**Figure 2.** Hearing thresholds [2].

Subject	3D FE	2D FE 60 slice survey	2D FE MS, heart long axis	Bal turbo FE, heart short axis	Turbo FE 1-shot RT Interactive
SPL, unwtd	109.5	109.9	111.5	107.6	115.9
SPL, A-wtd	109.5	110.3	111.6	106.2	116
Human subj, wtd	110.2	112	112.1	105.9	116.8
Pig, wtd	94.2	95.3	96.2	91	100.8
Dog, wtd	97.2	100.6	99	93.9	104.9
Cat, wtd	109.6	112.1	111.5	105.6	116.8
Rabbit, wtd	96.1	100	97.8	92.8	104
Norway rat, wtd	77.2	86.1	79.6	81	91.2