The impulse noise of TMS inside a 3T MRI scanner

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Introduction

- The operation of transcranial magnetic stimulation (TMS) coil produces high intensity impulse noise in the form of clicking sound, which can cause safety concerns, particularly when TMS is in side a magnetic resonance imaging (MRI) scanner [1].
- We measured the sound power levels (SPL) generated by the TMS coil inside a 3T MRI scanner.

Methods

- MRI-compatible TMS coil (MagPro R30 stimulator and MRi-B91 TMS-coil, Magventure, Denmark) inside a 3T MRI scanner (Skyra, Siemens, Erlangen, Germany).
- TMS coil was oriented either in parallel or in perpendicular to the main magnetic field of MRI.
- The electric field of TMS was measured to be 100 V/m at 93% Maximum Stimulator Output (MSO) using dedicated device [2].
- The sounds were measured by a microphone (MKE-PC2, Sennheiser electronic GmbH & Co. KG, Germany) firmly attached to the end of a non-elastic tube located outside the MRI shielding room and recorded (RME Babyface Pro, Audio AG, Germany). The measurement system was calibrated in the Aalto acoustics laboratory.
- The frequency range was between 20 and 20,000 Hz and the measurements were filtered by C-weighting.

Conclusions

- **The maximum of the measured SPL measured was 141 dB(C)**, higher than the maximum allowed by regulations without hearing protection (140 dB (C)). **Hearing protection is obligatory in TMS-MRI experiments**
- Separating the scalp and the TMS coil by an air space or porous materials is highly recommended to reduce acoustic noise level transmitted through the skull.

[1] Adreas Bungert, TMS combined with fMRI (PhD Thesis). University of Nottingham, December 15, 2010.
[2] Jaakko O. Nieminen et al. Experimental Characterization of the Electric Field Distribution Induced by TMS Devices. Brain Stimulation 8:582-589, 2019.

Results

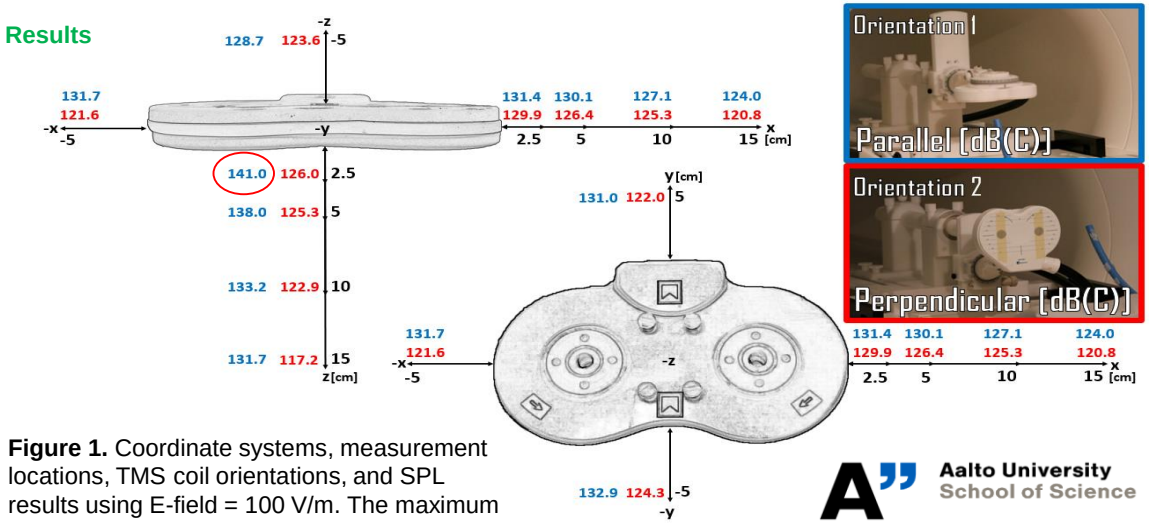

Figure 1. Coordinate systems, measurement locations, TMS coil orientations, and SPL results using E-field = 100 V/m. The maximum SPL is circled.

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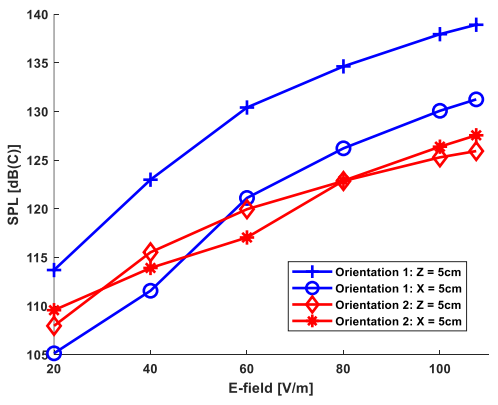

Figure 2. The effect E-field to SPLs at different locations and TMS coil orientations.

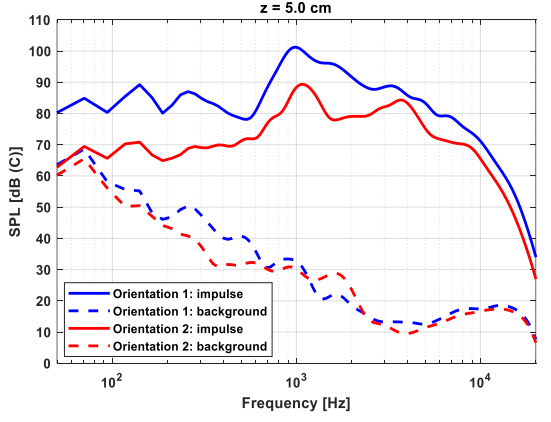

Figure 3. 1/3 octave sound spectrum of TMS impulse sounds and background noise. E-field = 100 V/m