 DOI: 10.3217/978-3-99161-050-2-162

Preliminary Evaluation of the Safety of Single-Parameter Ultrasound Stimulation on the Visual Cortex in Rats

Shupeng Tao[1], Jiande Guo[1], Weiming Zhang[1], Xizi Song[1*]

[1]*Academy of Medical Engineering and Translation Medicine, Tianjin University, Tianjin, 300072, China*

[*]Nankai District.Weijin Road.92, Tianjin, China. E-mail: songxizi@tju.edu.cn

Introduction: With the rapid development of Brain-Computer Interface (BCI) technology, ultrasound has emerged as a promising tool with significant potential for non-invasive applications[1]. However, a clear consensus on the safety parameters and evaluation protocols for ultrasound-based brain stimulation is still lacking, and existing data are insufficient to establish comprehensive guidelines[2，3]. This study investigates the safety of ultrasound stimulation on the visual cortex of rats under specific parameters, providing a multidimensional evaluation across three key aspects: blood-brain barrier integrity, histological analysis, and electrophysiological signal assessment.

Material, Methods and Results: This study used 12 male Wistar rats (260–300 g) and applied a 1 MHz focused ultrasound transducer to stimulate the left visual cortex. Stimulation parameters were: pulse repetition frequency (PRF)=1000 Hz, tone burst duration (TBD)=10μs, spatial peak pulse average intensity(I_{sppa})=3.15 W/cm², spatial peak temporal average intensity(I_{spta})=3.15 mW/cm², mechanical index (MI)=0.12, sound pressure=1.57 MPa, and a single stimulation duration of 60 seconds. Blood-brain barrier integrity was assessed using Evans blue dye injection, histological damage was evaluated with hematoxylin and eosin (H&E) staining, and steady-state visual evoked potentials (SSVEP) were analyzed with electrodes combined with LED. H&E staining and blood-brain barrier verification results are shown in Fig. 1. Results showed no blood-brain barrier disruption or tissue damage. SSVEP analysis indicated that ultrasound exposure did not alter the rats' steady-state responses to specific frequency visual stimuli.

Conclusion: This study demonstrates the safety of focused ultrasound stimulation on the visual cortex under specific parameters. A multidimensional assessment of the safety of ultrasound stimulation provides valuable data supporting the development of non-invasive BCI technologies.This foundation also provides insights for further optimization of parameter design and establishing standardized safety assessment protocols.

Acknowledgments and Disclosures: This research was supported by the National Natural Science Foundation of China (No. 62276183, 81925020, 81630051).

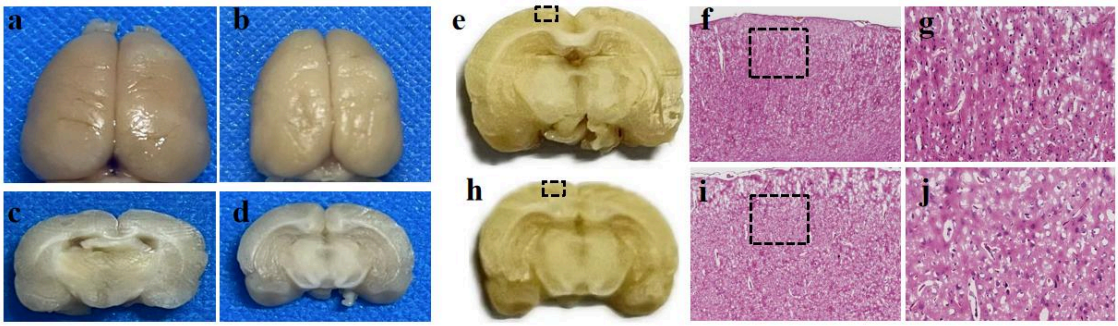

Figure 1: **a-b**: Evans blue dye extravasation for control and experimental groups; **c-d**:Coronal sections of brain tissues. **e–j:** Results of H&E staining; original magnification ×10 (f,i), ×40 (g,j). Black boxes represent the area depicted in the following panel.

References:

[1] Zheng H, Niu L, Qiu W, Liang D, Long X, Li G, Liu Z, Meng L. The emergence of functional ultrasound for noninvasive brain–computer interface. Research, 6:Article 0200, 2023.

[2] Pasquinelli C, Hanson LG, Siebner HR, Lee HJ, Thielscher A. Safety of transcranial focused ultrasound stimulation: A systematic review of the state of knowledge from both human and animal studies. Brain Stimulation, 12:1367-1380, 2019.

[3] Blackmore J, Shrivastava S, Sallet J, Butler CR, Cleveland RO. Ultrasound neuromodulation: A review of results, mechanisms, and safety. Ultrasound in Medicine & Biology, 45(7):1509–1536, 2019.

 Published by Verlag der Technischen Universität Graz