 DOI: 10.3217/978-3-85125-962-9-7

Deep learning-based diagnosis of tinnitus using EEG signals

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Introduction: Tinnitus is a neuropathological phenomenon caused by the recognition of external sound that does not actually exist. Existing diagnostic methods for tinnitus are rather subjective and complicated medical examination procedures. The present study aimed to diagnose tinnitus using deep learning analysis of electroencephalographic (EEG) signals while patients performed auditory cognitive tasks.

Material, Methods, and Results: Patients with tinnitus (n=11) and age/sex-matched healthy volunteers (n=11) performed an active oddball task and a passive oddball task during EEG acquisition. During the active oddball task, patients with tinnitus could be identified with an area under the curve (AUC) of 0.886 through a deep learning model (EEGNet [1]) using EEG signals (Fig. 1A). Importantly, an analysis of the EEGNet convolutional kernel weights revealed interpretable tinnitus-related features in the alpha band, consistent with prior literature (Fig. 1B).

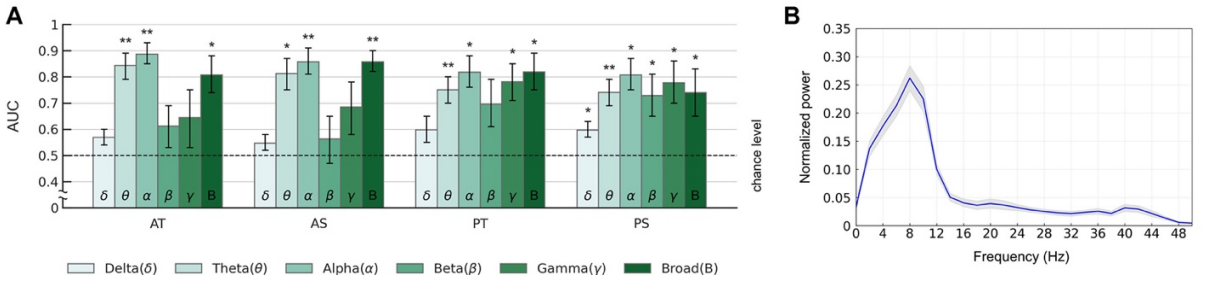

Figure 1. EEGNet model classification performance of tinnitus patients vs. healthy controls in the EEG oddball task. *A) AUC scores of the EEGNet model across different frequency bands and stimulus types. B) Normalized spectral power of the weights of the first EEGNet convolutional layer. Weights were projected on the frequency domain using Fast Fourier Transform. AT: active oddball task, target stimuli; AS: active oddball task, standard stimuli; PT: passive oddball task, target stimuli; PS: passive oddball task, standard stimuli. Error bars represent standard errors of the mean (*, $p < 0.05$; **, $p < 0.005$).*

Discussion: This study demonstrated that human EEG signals provide promising tinnitus identification features, particularly in EEG alpha band, that enable practical tinnitus-diagnostic applications.

Significance: Our findings suggest that task-relevant EEG features can be considered a neural signature of tinnitus symptoms and support the feasibility of EEG-based deep-learning approach for the diagnosis of tinnitus.

Acknowledgements: This work was supported by the Convergent Technology R&D Program for Human Augmentation (2020M3C1B8081319) through the National Research Foundation of Korea.

References

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