Clinical Neurophysiology 130 (2019) 1997

Contents lists available at ScienceDirect

Clinical Neurophysiology

journal homepage: www.elsevier.com/locate/clinph

Letter to the Editor

Reply to "Artificial intelligence in the field of electrodiagnosis – A new threat or heralding a new era in electromyography?"

We would like to thank Jeon et al. (2019) for their interest in our recently published paper 'Deep learning for waveform identification of resting needle electromyography signals' (Nodera et al., 2019).

First, regarding their points on the technical aspects, we fully agree that our work should be regarded as a proof-of-concept study to demonstrate applicability of deep learning methodology to needle electromyography (nEMG) signals. In contrast to the recent rapid advance of artificial intelligence (AI) on medical image analyses, AI application on electrical signals has been much slower. This could have been partially due to complex nature of signals due to large, constantly flowing data regarded as audio (e.g., 44,100 samplings per second in a regular CD album), that can be either assessed as time domain waveforms (as seen in an oscilloscope) or in the time-frequency domain (by converting raw signals into spectrograms), none of which has stood out yet. We decided to use the latter methodology to convert nEMG signals into Mel-spectrogram audio-visualization image data that were fed into a deep learning system. As correctly commented by Jeon et al., there are a number of fine-tuning techniques to improve accuracy while avoiding overfitting of the provided dataset. Overfitting would prevent the model from being used in wider settings. We also admit that the number of data is not adequately large, due to a single-center study and providing 2-second clean data that had only a single nEMG finding throughout the recording. Obviously, more studies should be performed to achieve our ultimate goal to create an AI-based nEMG diagnostic system. To do so, at least the following should be employed: (1) inclusion of more nEMG data (e.g., larger number of data per finding and more variety of discharges, such as insertional activity, neuromyotonia, myokymic discharges, etc.), (2) use of a variety of data conversion methods, such as raw signals, spectrogram, Mel-spectrogram, etc., (3) application of various deep learning methodologies, such as dropout, combined models, the use of pre-trained weights vs. 'training from scratch'.

Second, the argument of Jeon et al. on the future of electromyographers in the AI era is very intriguing. Because some nEMG discharges are rather subjectively defined, there will always be some room for individualized interpretation on nEMG signals. At this moment, therefore, we do not consider that AI threatens experienced electromyographers, because humans have to set 'ground truth' data with nEMG findings to begin training of an AI system. Furthermore, factors such as patients' ages and anatomical characteristics (e.g., limb vs. cranial muscles) do affect the interpretation that requires a huge dataset to cover all of these concerns. Unlike board games such as chess and go that surpassed human top players by AI, an AI-based nEMG identification system should be complementary to expert electromyographers' clinical practice. Knowledge and experiences of expert electromyographers are certainly needed to insert a needle electrode into a correct muscle and to obtain signals of adequate quality for assessment, that cannot be performed by a machine at all. So, to our fellow electromyographers, AI is not our enemy!!

Funding

This work was supported by JSPS KAKENHI Grant Number 17K09800.

Declaration of Competing Interest

None of the authors has conflict of interest to disclose.

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Available online 24 June 2019

DOI of original article: https://doi.org/10.1016/j.clinph.2019.06.005

https://doi.org/10.1016/j.clinph.2019.06.004
1388-2457/