DEVELOPMENT OF METHODS TO EXTRACT NEURONAL SOURCES FROM THE ACTION POTENTIALS GENERATED BY POPULATIONS OF MOTOR NEURONS

Instituto Universitario de Investigación de Ingeniería de Aragón
Universidad Zaragoza

Javier Yanguas, Pablo Laguna, Jaime Ibáñez
University of Zaragoza
Biomedical Signal Interpretation and Computational Simulation (BSICoS)

erc Starting Grants
BSICoS Biomedical Signal Interpretation & Computational Simulation

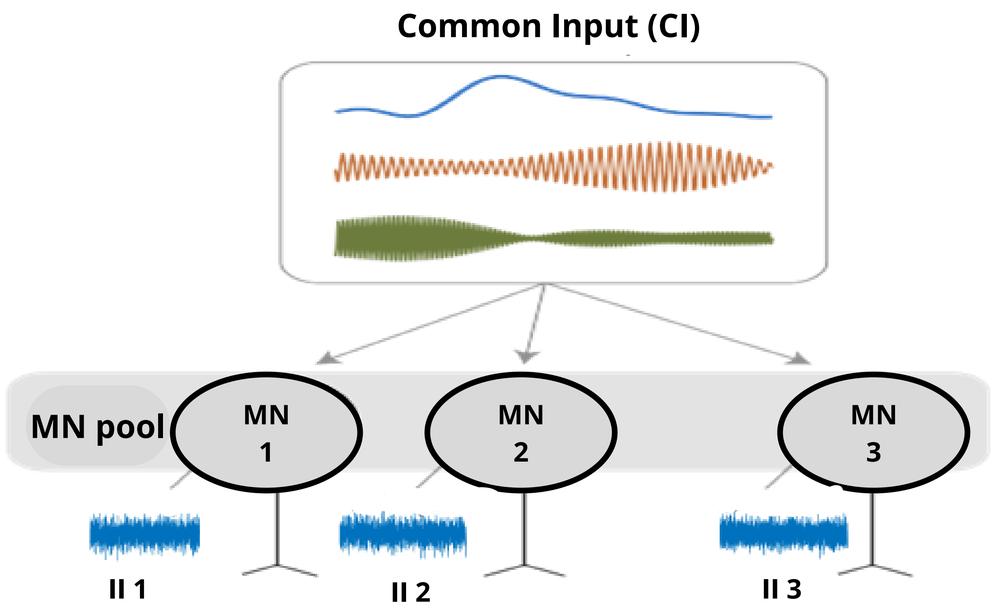
XIII JORNADA DE JÓVENES INVESTIGADORES DEL I3A

EMAIL: jyanguas@unizar.es

INTRODUCTION

- Motor Neurons (MN) transform neural information into movement by connecting the brain (and other sources) to the muscles.
- Pools of several MN innervating a muscle act as a linear system, where MN are often modelled as elements receiving common inputs (CI) and independent inputs (II). Lack of independent activity in MN is defined as synchronization.

OBJECTIVE: Study the sampling capacities of the MN to develope advanced methods of extraction and source separation methods. A validated and realistic computational neuronal model is used.



RESULTS

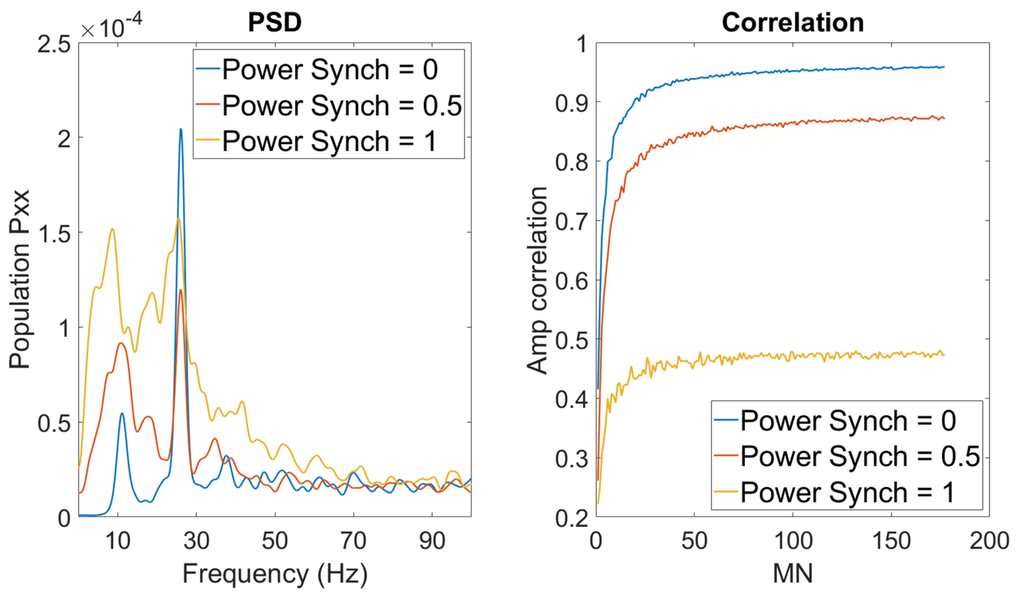


Fig 2 Left: PSD of cst of 30 MN under 3 synchronization levels, defined by increasing the power of the 0-10 Hz CI. The main CI was at 26 Hz. **Fig 2 Right:** Amplitude correlation between main CI and cst of each of the synchronization levels.

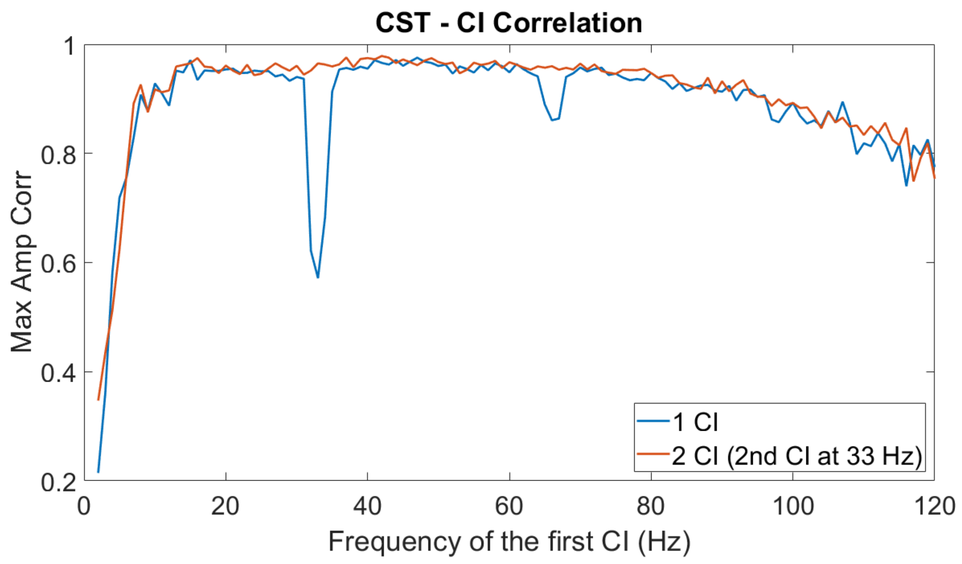


Fig 3: maximum amplitude correlation between cst and CI (177 MN) when using 1 CI vs 2 CI. Frequency of the first CI is at frequencies between 2 to 120 Hz. In the case including other CI, it is at 33 Hz. Correlation achieved per frequency is the same for both conditons unless overlapping frequencies

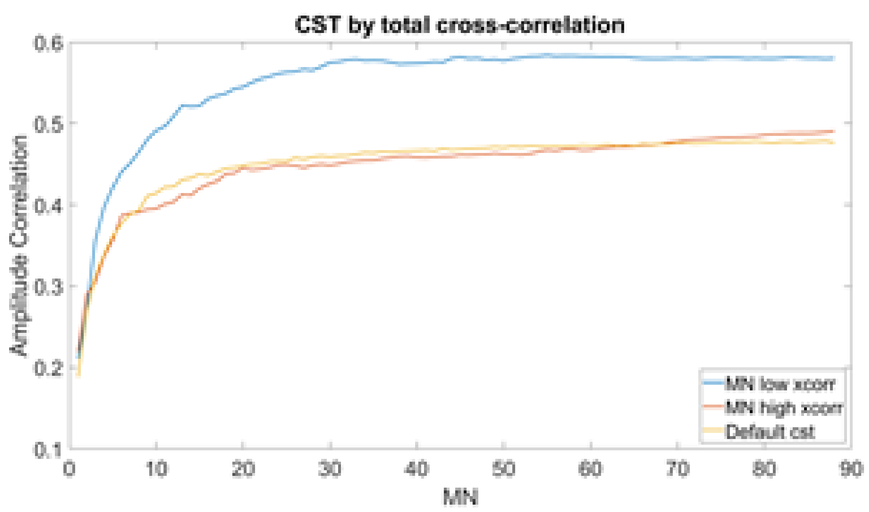


Fig 4: correlation obtained by grouping the more synchronized MN and the less synchronized MN, where synchronization is quantified by the average peak of the cross-correlogram between each pair of MN

METHODS

- Decoding capacity is measured by amplitude correlation between CI and cumulative spike train (cst). In one condition, only one CI is simulated (signal to be decoded) varying its frequency across simulations. In the other, an extra CI of 33 Hz is added (interference signal). II are modeled as white noise with mean equal to variance.
- For the study of synchronization, we model two different CI: one bandpass filtered around the frequency to decode and the other low-pass filtered at 10 Hz.
- Synchronization is regulated by changing the ratio between the power of the low frequency CI (0-10 Hz) and the power of the II.

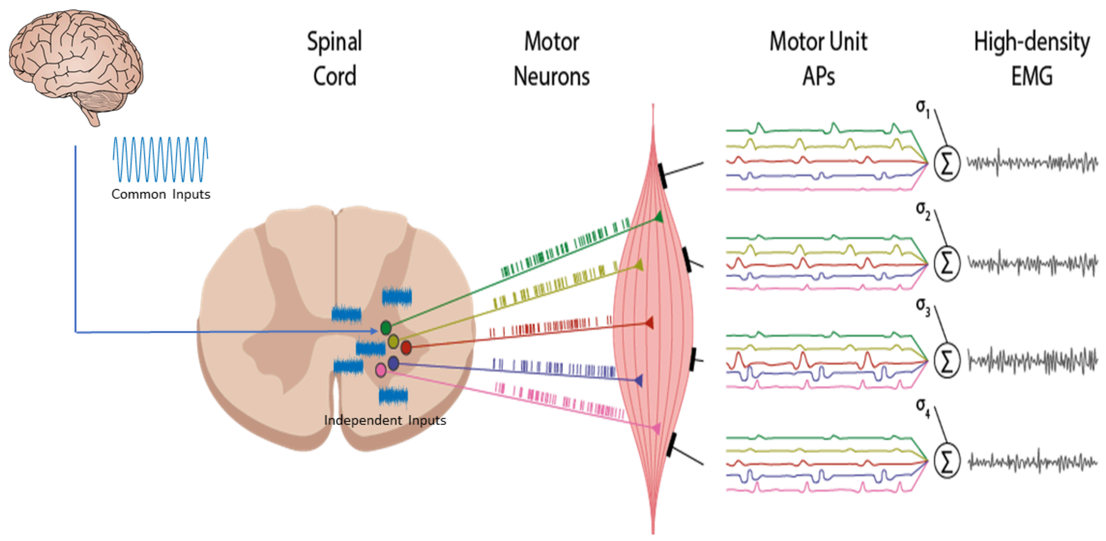


Fig 1: Overview of the model. The model simplifies all the MN inputs by grouping them into CI or II. MN are modelled as two-compartment with Hodgkin-Huxley style kinetics

CONCLUSIONS

- MN pool can reliably transmit signals of a huge range of frequencies. CI can be transmitted in presence of interference signals of different frequencies.
- MN synchronization reduces extraction capacity of CI.
- Less synchronized MN are more informative about CI.

BIBLIOGRAPHY

1. E. R. Williams, S. N. Baker, Circuits generating corticomuscular coherence investigated using a biophysically based computational model. I. Descending systems. Journal of Neurophysiology 101, 31-41 (2009).
2. M. Bracklein, D. Y. Barsakcioglu, A. Del Vecchio, J. Ibañez, D. Farina, Reading and modulating cortical β bursts from motor unit spiking activity. Journal of a42, 3611-3621 (2022).
3. D. Farina, F. Negro, Common synaptic input to motor neurons, motor unit synchronization, and force control. Exercise and Sport Sciences Reviews 43, 23-33 (2015)