# Computing Motor Modules with an Autoencoder Enables Stronger Confidence in Module Structure & Functional Interpretability

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## Autoencoders as an improved method to computing motor modules

- Motor modules are computed groupings of co-active muscles, often used in analysis of motor control compexity in individuals with neurological injuries[1].
- The standard for motor module computation is non-negative matrix factorization (NMF).
- With NMF, the selection of the number of modules can significantly impact module structure and corresponding analysis[2].
- Autoencoders are a neural network based approach to dimensionality reduction, with potential to improve consitency in module structure.

### Objective:

The aim of this work is to implement autoencoder based motor module computation to improve consitency in module structure, while maintaining known trends module count for post-stroke individuals.

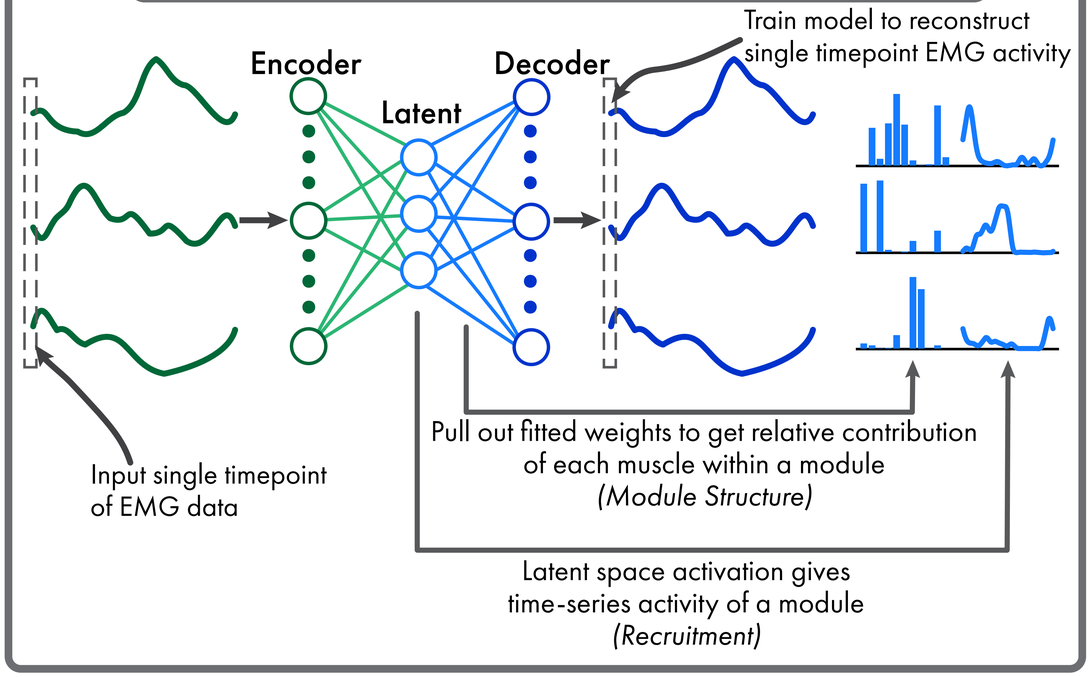
### Datasets

- 21 Able-body individuals, 11 muscles unilateral[3]
- 52 Post-stroke individuals, 8 muscles bilateral[4]

### Motor Module Extraction & Analysis

- Modules were iteratively from 1 module up to the number of muscles present.
- Similarity in corresponding modules at each module count was evaluted by pearson's correlation.
- For post-stroke individuals, paretic and non-paretic data was used in order to compare number of modules and variance accounted for between each leg

## Autencoder-Based Motor Module Process

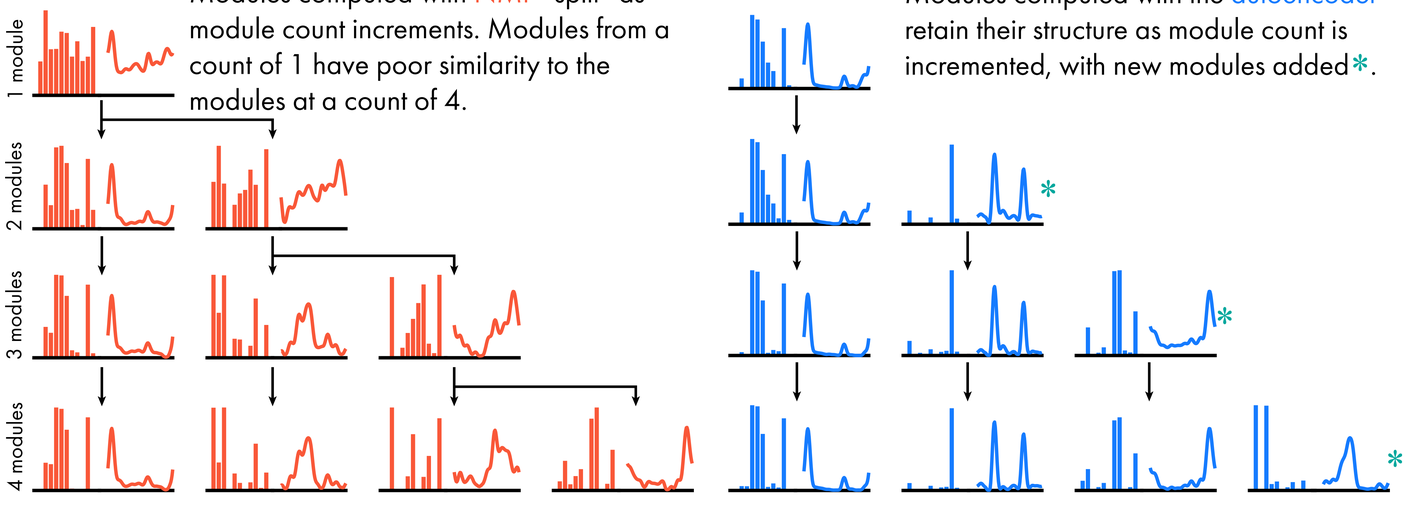



## Module Consitency is Improved with Autoencoder

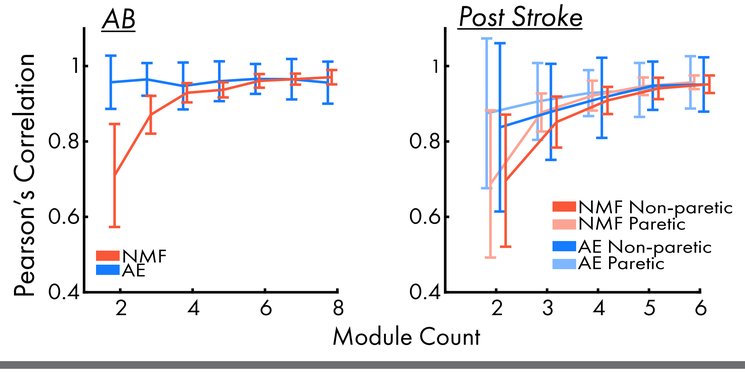
*Representative AB Subject*

Modules computed with NMF "split" as module count increments. Modules from a count of 1 have poor similarity to the modules at a count of 4.

Modules computed with the autoencoder retain their structure as module count is incremented, with new modules added*.



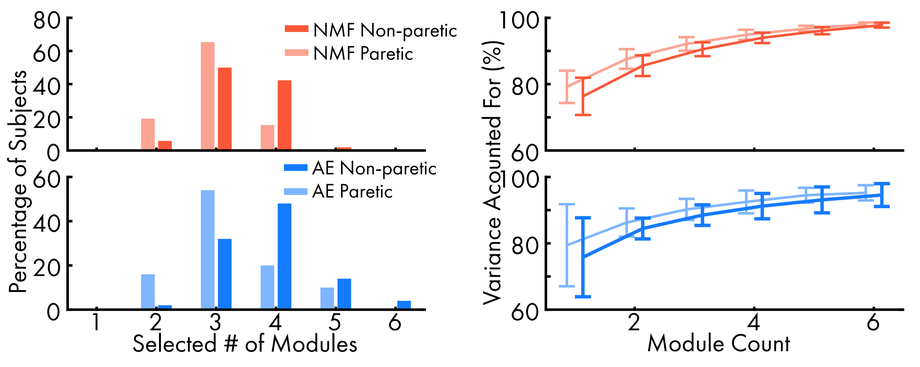

Module Structure Agreement




The autoencoder shows significantly stronger agreement in module structure, irrespective of module count indicating more consistent information within each module.

The autoencoder presents modules with a more distinct function at low module counts when compared NMF.

## Motor Module Trends in Post-Stroke Individuals




The autoencoder confirms trends in motor module count between the paretic and non-paretic limbs. Like with NMF, the autoencoder shows the paretic limbs tend to lower number of modules and a higher VAF % at a given module count, when compared to the non-paretic limb.

## *Conclusion*

**Autoencoders present a promising alternative to the state of the art method for computing motor modules.**

The autoencoder based method showed stronger consistency in computed module structure and recruitment, while still capturing the motor control differences in a population with a neurological injury.

### References

1) Clark DJ, et al., Merging of healthy motor modules predicts reduced locomotor performance and muscle coordination complexity post-stroke. J Neurophysiol. 2010 Feb
2) Banks CL, et al., Methodological Choices in Muscle Synergy Analysis Impact Differentiation of Physiological Characteristics Following Stroke. Front Comput Neurosci. 2017 Aug
3) Camargo J et al., A comprehensive, open-source dataset of lower limb biomechanics in multiple conditions of stairs, ramps, and level-ground ambulation and transitions, Journal of Biomechanics. 2021