Exploring Novel Methodological Approaches for the Analysis of Electroencephalogram Data: Machine Learning and Group Iterative Multiple Model Estimation

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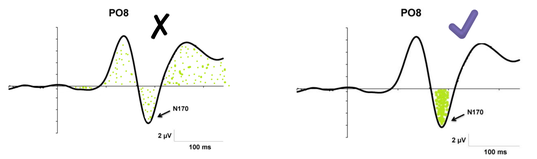
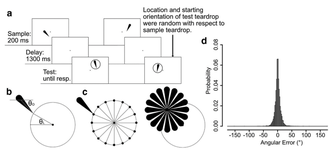
Background

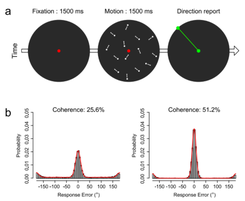




TEARDROP STIMULUS STUDY
(BAE & LUCK, 2018)

Which time points have information?

Can we find neural mechanisms or connectivity at those time points?



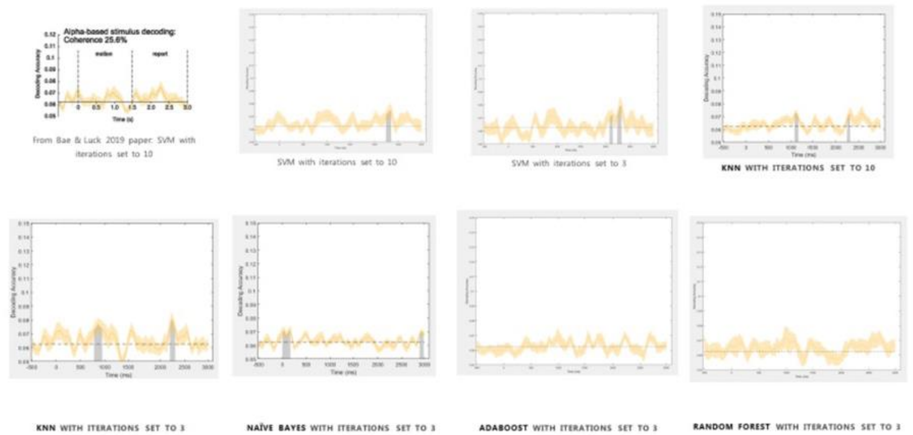
MOTION PERCEPTION STUDY
(BAE & LUCK, 2019)

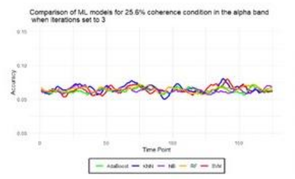
Is SVM the best model? What about other ML models?

In the low coherence condition, is response random?

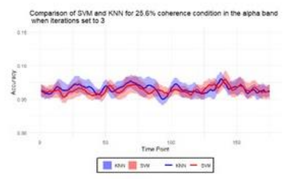
Aims/Hypotheses	Methods
25.6% coherence condition: behavioral responses will be more precise than random responses	Simulated von Mises distribution, compared estimated and true kappas using z-test.
Alpha band EEG and sustained ERP from the 25.6% condition yield significant information	Utilized machine learning models (SVM, KNN, NB, RF, AdaBoost) for EEG decoding analyses
Replicate results using SVM model	Conducted analysis with SVM model under ten iterations and compared results to original analysis.
Explore if other machine learning models perform better than SVM	Compared decoding accuracies of models (SVM, KNN, NB, RF, AdaBoost) across time points
• Analyze ERP data for group-level differences a. Observe distinct connections between spatial attention and working memory • Analyze alpha band data a. Identify group-level connectivity for spatial attention b. Observe no consistent connections for working memory	Utilized Confirmatory subgrouping GIMME. Used latent variables. Found an appropriate measurement model for the latent variables.

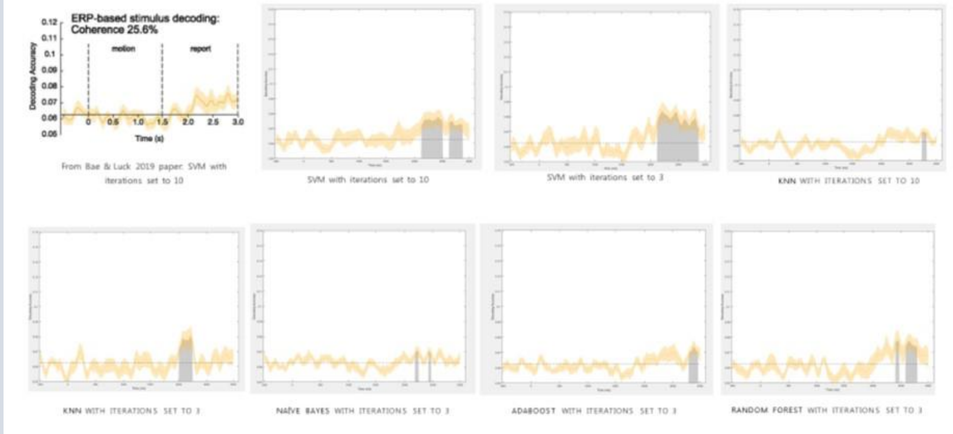
Results

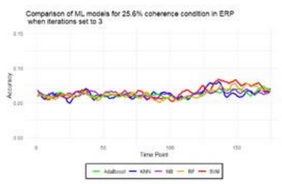




(a) For 25.6% coherence in alpha band significant time clusters (shaded in grey) identified for the five different models with three iterations and with SVM and KNN having iterations set to 10. (b) Decoding accuracies of all the models plotted together without confidence error bounds. (c) Decoding accuracies of SVM and KNN with three iterations drawn with confidence bounds. The CI bounds overlap indicating no model is superior to the other.







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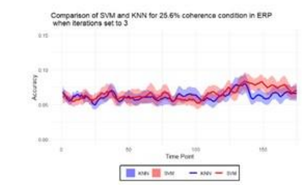
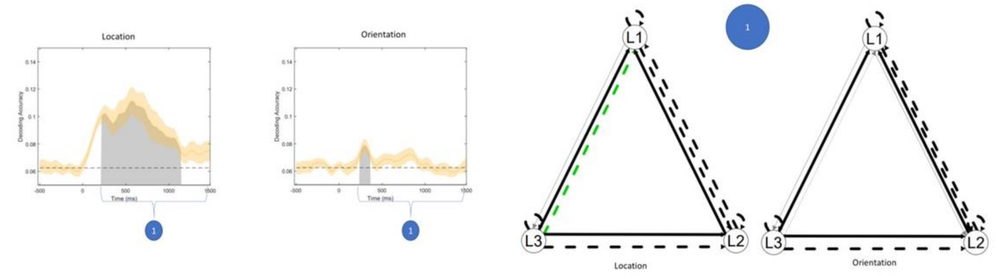
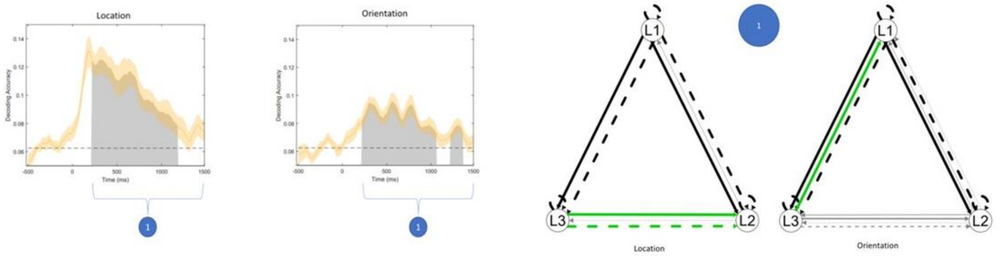




For the alpha band, confirmatory subgrouping GIMME is utilized to find effective connectivity differences in the location and orientation condition subgroups. (a) The output from SVM with iterations set to ten, with the significant time clusters marked in gray. The time points marked "1" are approximately the time points on which GIMME was used. (b) GIMME output for 244 ms-1480 ms.



For the sustained ERP data, confirmatory subgrouping GIMME is utilized to find effective connectivity differences in the location and orientation condition subgroups. (a) The output from SVM with iterations set to ten, with the significant time clusters marked in gray. The time points marked "1" are approximately the time points on which GIMME was used. (b) GIMME output for 244 ms-1480 ms.

Check out my website!

To see the rest of the results, read the honors thesis, or just get in touch with me

Conclusion

MACHINE LEARNING

Motion perception: We can perceive direction of motion even in low coherence.

Working memory: Alpha band does not have decodable information on working memory.

Spatial attention: Decodable information present in alpha band and ERP.

Best model: Nope! Look for converging results.

GIMME

Working memory: Parietal to frontal connectivity uncovered in ERP.

Spatial attention: Right to left parietal connectivity uncovered in ERP and parietal to frontal synchrony found in alpha band.

Convergence: Works best with longer time series and with specific measurement models.

LIMITATIONS

Validation studies are needed to validate these new methods.

Measurement model: To enable convergence only one measurement model could be used with GIMME. Such rigidity is concerning.

Downsampling was required to enable convergence. This may lead to loss of important information.

FUTURE DIRECTIONS

Simulation studies that replicate the unique properties in EEG will help discover optimal parameters for the algorithms.

Determine bias: Simulations will help uncover bias, if present, in GIMME estimates.

Identifying the measurement model by developing new methods or making an ice-cream sandwich of classical methods.

References

Bae, G.-Y., & Luck, S. J. (2018). Dissociable Decoding of Spatial Attention and Working Memory from EEG Oscillations and Sustained Potentials. *The Journal of Neuroscience*, *38*(2), 409–422. https://doi.org/10.1523/jneurosci.2860-17.2017

Bae, G.-Y., & Luck, S. J. (2019). Decoding motion direction using the topography of sustained ERPs and alpha oscillations. *NeuroImage*, *184*, 242–255. https://doi.org/10.1016/j.neuroimage.2018.09.029