Comparison of various functional connectivity estimation methods in developing different machine learning techniques to predict chronic pain

McGill

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Introduction

Most of the functional magnetic resonance imaging (fMRI) investigations conducted to date have used the assumption that there is consistent functional connectivity (FC) between time series from different brain areas. There has been increasing interest in quantifying potential dynamic changes in FC during fMRI investigations as it is believed that doing so may shed light on the basic operation of brain networks. However, a growing body of research in neuroimaging suggests that functional networks show dynamic changes in connection strength as well as variable phase difference (nonzero time-lag) between regions.

Aims / Hypothesis

Our goal is to compare various functional connectivity estimation techniques that address these problems and demonstrate their effect in developing and evaluating machine learning (ML) in predicting chronic pain.

Methods

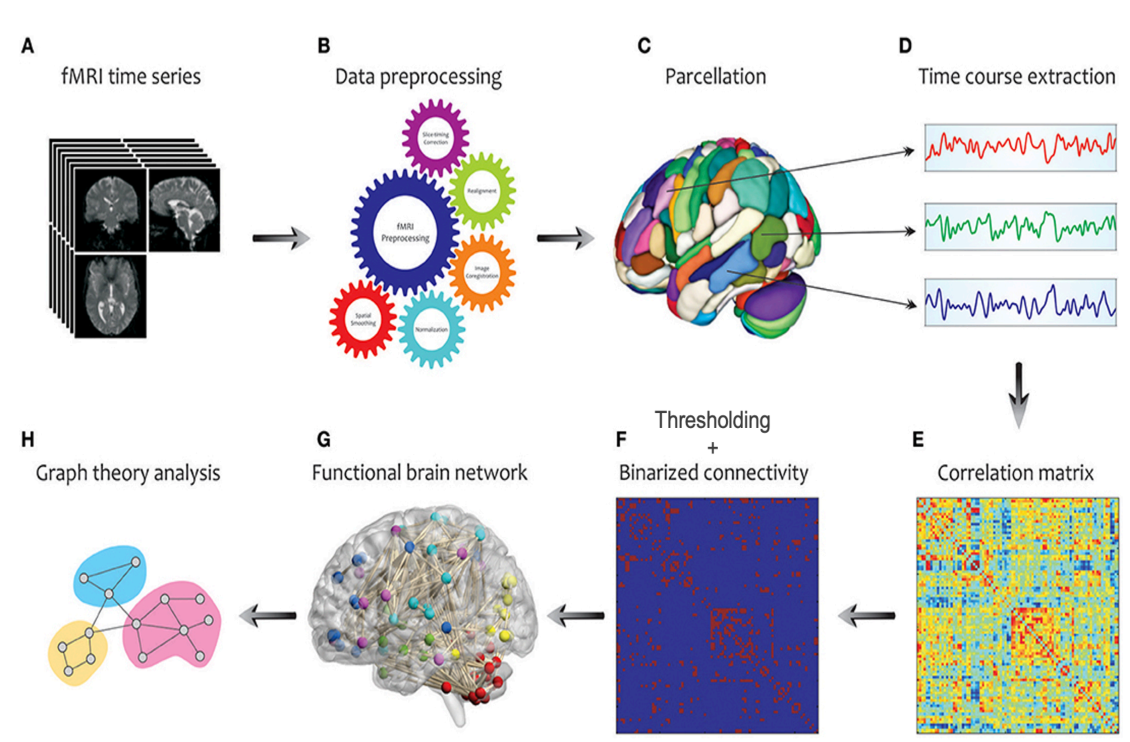


Figure 1: *Data Preprocessing Overall Workflow*

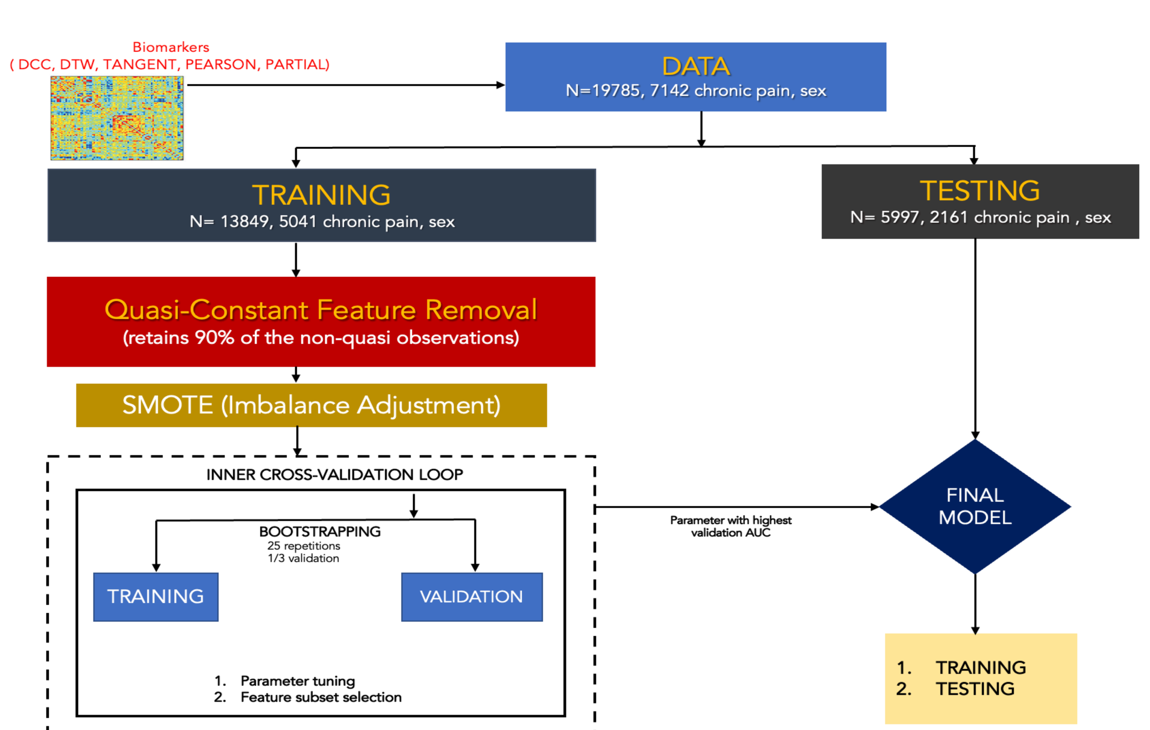


Figure 2: *Machine Learning Overall Pipeline*

Results

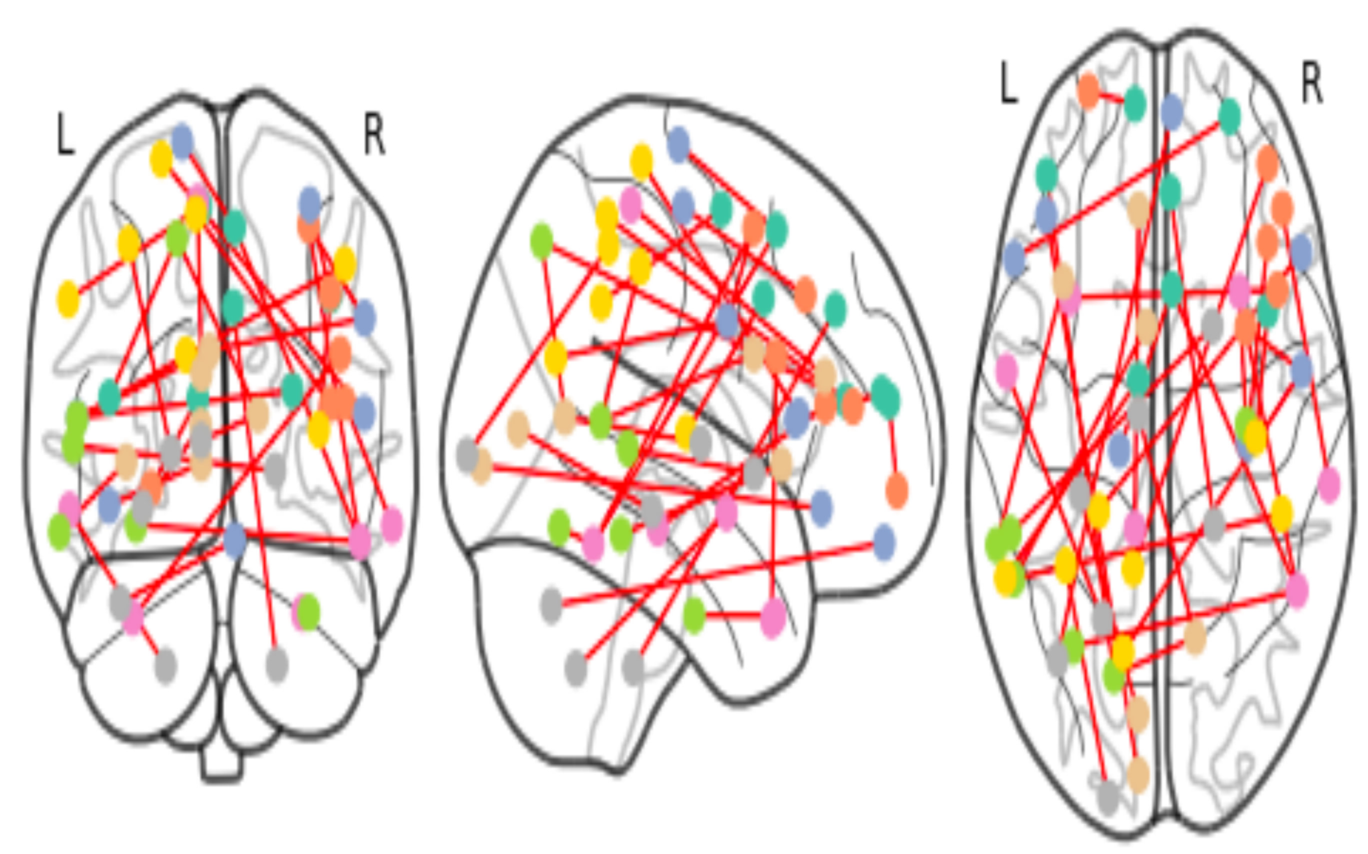


Figure 3: *Visualization of the absolute connectivity from the top 30 Important Features in LR using Partial Correlation. computed from resting-state functional Magnetic Resonance Imaging (rsfMRI).*

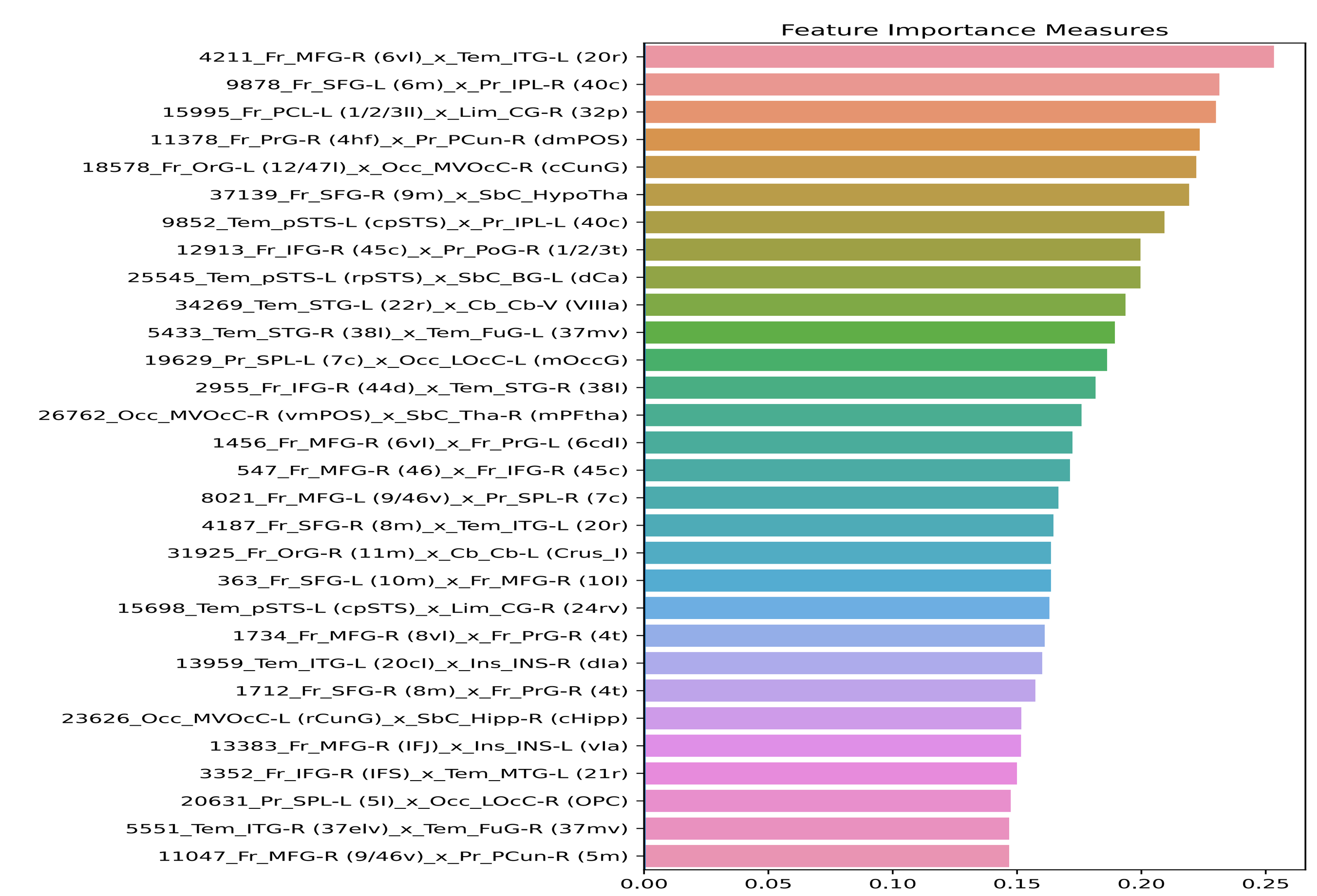
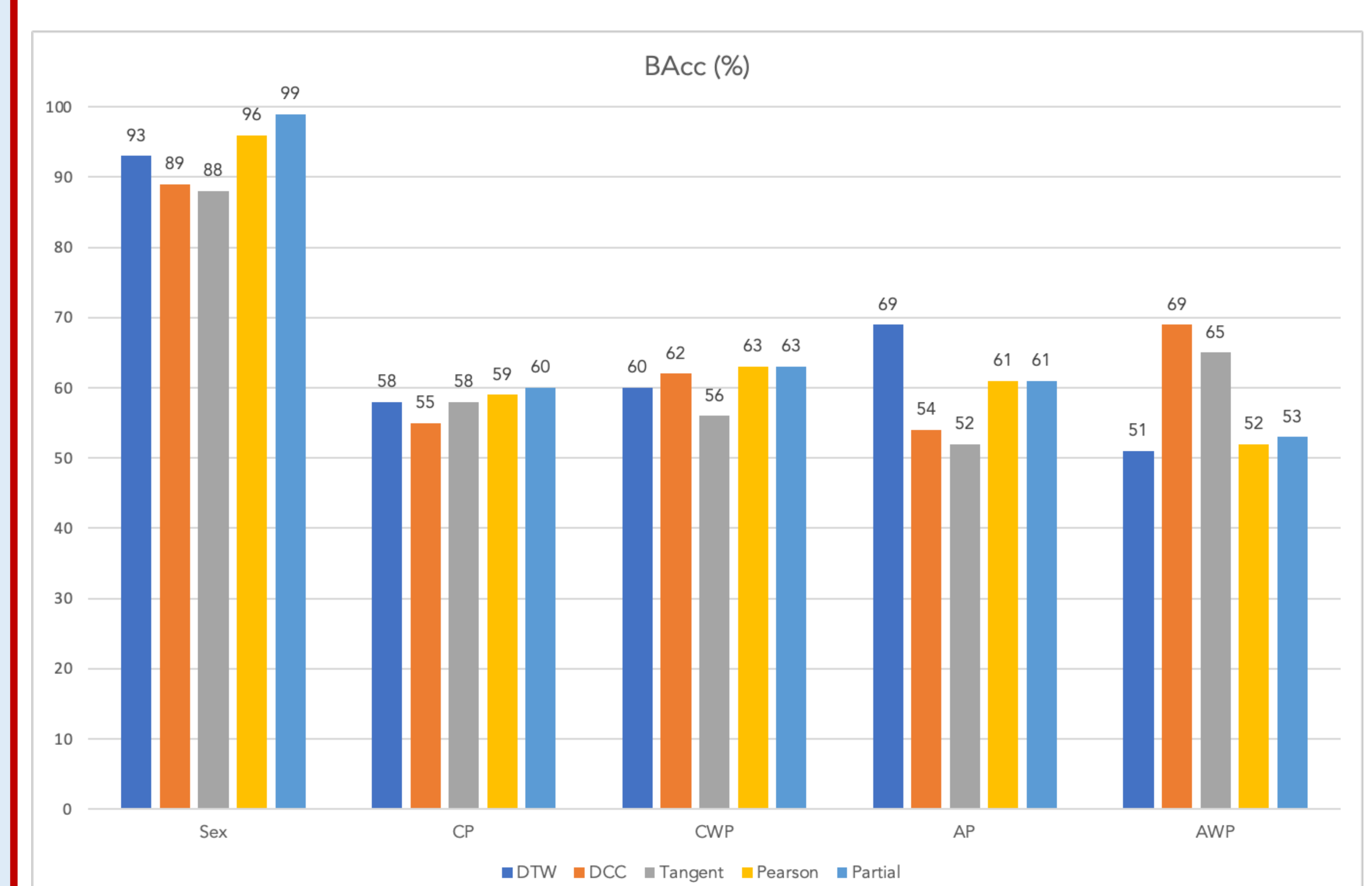
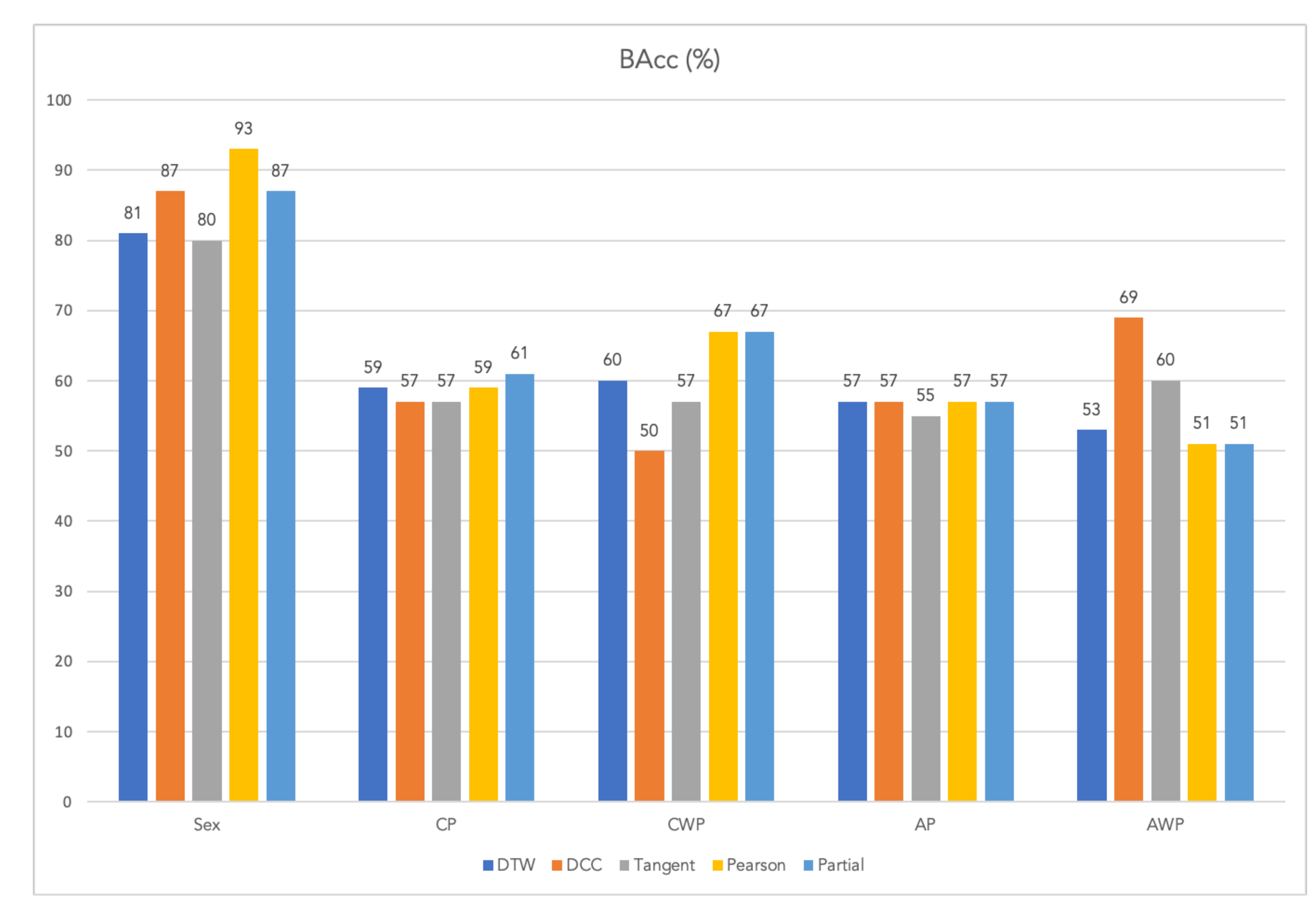


Figure 4: *Top 30 Important Features in LR using Partial Correlation.*



Logistic Regression



XGBoost

Figures 5 and 6: *Performance metrics evaluation of predictive models in testing sets using the LR and XGB models.*

FCM	AUC (%)				
	Sex	CP	CWP	AP	AWP
DTW	85	53	55	51	45
DCC	81	52	57	49	69
Tangent	80	53	51	49	63
Pearson	88	54	58	49	49
Partial	93	55	58	49	49
Significance level	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Logistic Regression

FCM	AUC (%)				
	Sex	CP	CWP	AP	AWP
DTW	81	54	56	50	47
DCC	81	52	57	49	56
Tangent	80	53	48	50	66
Pearson	87	52	58	49	49
Partial	89	53	58	49	47
Significance level	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

XGBoost

Tables 1 and 2: *Performance metrics evaluation of predictive models in testing sets using the LR and XGB models.*

Discussion

- In discriminating sex, Partial and Pearson correlations provided a consistent performance when using in 6 ML algorithm (AUC: 0.88, 0.85, 0.87, 0.87, 0.87, 0.87 and 0.93, 0.65, 0.88, 0.85, 0.80, 0.74 respectively).
- On the other hand, in predicting chronic pain, DCC and Pearson correlation provided a relatively better performance when using in 6 ML algorithm (AUC: 0.53, 0.53, 0.54, 0.54, 0.54, 0.52 and 0.55, 0.51, 0.53, 0.53, 0.55, 0.53 respectively).
- The 5 various functional connectivity estimation techniques affect the performance on whatever ML algorithms are performed in predicting either chronic pain or sex. However, the 6 different ML pipelines were consistent in the performance of predictive brain-based biomarker models.

References

1 Vachon-Presseau, et al. (2016). The emotional brain as a predictor and amplifier of chronic pain. *Journal of Dental Research.*

2 McConnell, et al. (2020). Impaired frontostriatal functional connectivity among chronic opioid using pain patients is associated with dysregulated affect. *Addiction Biology*

3 Wu, et al. (2019). Genome-wide association study of medication-use and associated disease in the UK Biobank. *Nature Communications.*

Acknowledgements

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