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Learning Generalized Features from EEG

using Deep Learning for a Cognitive Brain-Computer Interface

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Introduction:

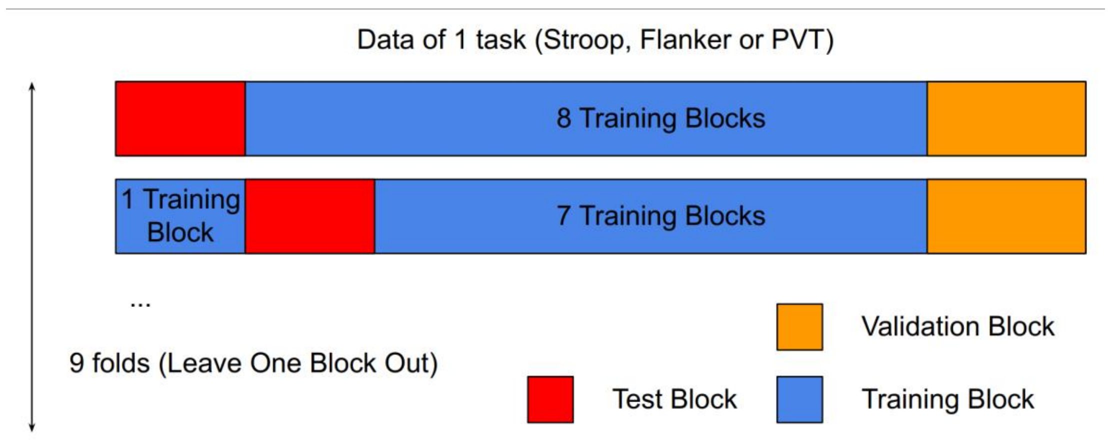
Attention-based Electroencephalography (EEG) Brain-Computer Interfaces (BCIs) are important during patient diagnosis or experiments, in detecting human attention disorders such as Attention Deficit Hyperactivity Disorder (ADHD) which can have severe adverse effects on one's quality of life.

Motivation:

Attention can be measured by cognitive tasks like the Stroop Test, Eriksen Flanker Test and Psychomotor Vigilance Test (PVT). Despite the all three cognitive tasks' different contents, they all require the use of visual attention. We compare Deep Learning models (EEGNet & TSception) vs. SVM via Intra-task and Inter-task experiments, where we aim to explore common hidden features and learn generalized representations from the EEG data across the 3 distinct cognitive tasks.

Intra-task Experiments:

Via Leave One Block Out Cross Validation, TSception has achieved significantly higher classification accuracies than other methods, with ***82.48%***, ***88.22%***, and ***87.31%*** for Stroop, Flanker and PVT tests, respectively. Our experiments also showed that the end-to-end Deep Learning methods showed higher performance over the SVM, which required manually extracted features.



Tasks	Methods	Segment length		
		1s	2s	4s
Stroop	SVM	66.56%***	69.31%***	71.61%**
	EEGNet	68.48%**	75.03%*	78.21%*
	TSception	**72.23%**	**77.99%**	**82.48%**
Flanker	SVM	74.53%*	76.38%*	76.39%**
	EEGNet	71.57%**	77.10%	77.26%*
	TSception	**78.46%**	**83.05%**	**88.22%**
PVT	SVM	73.86%*	76.32%**	78.09%**
	EEGNet	74.07%	80.67%	83.38%
	TSception	**77.43%**	**82.13%**	**87.31%**

*:p-value < 0.05; **:p-value < 0.01; ***:p-value < 0.001.
The p-value is calculated between TSception and other methods as TSception achieves the highest accuracy in all the experiments.

Inter-task Experiments:

Deep Learning methods showed superior performance over the SVM with most of the accuracy drops not being statistically significant ($p > 0.05$). Our experiments indicate that there is common hidden knowledge that exists across data from the different cognitive attention tasks, and that Deep Learning methods can learn generalised representations of the data better than the SVM.