9th International Work-Conference on the Interplay between natural and artificial computation (IWINAC 2022)

Temporal phase synchrony disruption in Dyslexia: anomaly patterns in auditory processing

Marco A. Formoso[1,3], Andrés Ortiz[1,3], Francisco J. Martínez-Murcia[2,3] , Diego Aquino Brítez[4] , Juan José Escobar[4], and Juan Luis Luque[5]

[1] Communications Engineering Department. ETS Ingeniería de Telecomunicación. University of Málaga
[2] Department of Signal Theory, Telematics and Communications. ETS Ingeniería de Telecomunicación. University of Granada
[3] Andalusian Data Science and Computational Intelligence Institute (DaSCI)
[4]Department of Computer Architecture and Technology, University of Granada.
[5]Department of Developmental and Educational Psychology University of Málaga.

1. Introduction
2. Methodology
3. Results
4. Conclusions

Introduction

- Developmental Dyslexia (DD) is a specific difficulty in the acquisition of reading skills not related to mental age or inadequate schooling.
- Difficulties in word recognition and by poor spelling and decoding abilities.
- Neural representation of the sequential sounds of speech.
- Prevalence is between 5% - 12% of the population.
- In children, it has effects in the self-esteem, could have an important social impact and eventually, may determine school failure.

- Dyslexia (DD) is usually diagnosed by means of specifically designed tests to measure different behavioural variables in the reading process.
- Reading efficiency or the ability to split words.
- Tests are individually applied by specialists.

- Classical diagnosis methods are time-consuming and prone to error.
- Results of the tests depend on the motivation and the mood of the child.
- Usually children with specific difficulties are not correctly diagnosed.
- Most benchmarks are designed for readers, limiting the minimum age for the early diagnosis.
- Early diagnosis and prognosis to start an adequate and individualized intervention is decisive in the personal and intellectual development of the children.

- We assume that there should be differences in brain reaction/adaptation between the control and dyslexic groups when an auditory stimulus is applied.

Methodology

- 48 Children:
  - 32 skilled readers (17 males / 15 females)
  - 16 dyslexic readers (7 males / 9 females)

- The mean age of Control group was: 94 months control group and 95 months from dyslexic group.

- All Participants were Spanish native speakers.

- Dyslexic children had all received a formal diagnosis in the school.

- We recorded EEG (500Hz sampling rate) signals using a 32 active electrodes while presenting auditory stimulus.
- White Noise Stimulus AM (5 minutes each): 4.8Hz, 16Hz, 40Hz, 40Hz, 16Hz, 4.8Hz
- EEG signals were pre-processed in order to remove artefacts related to eye blinking.
- These artefact were removed by blind source separation using Independent Component Analysis (ICA)
- EEG referenced to Cz channel

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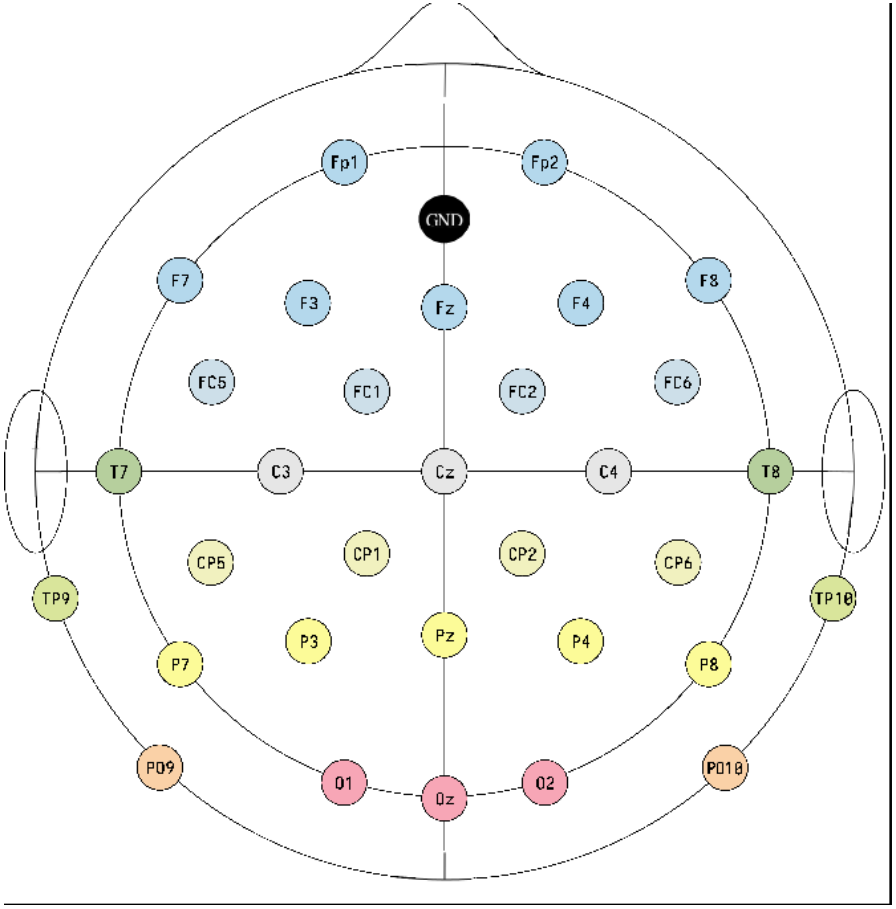

Methodology

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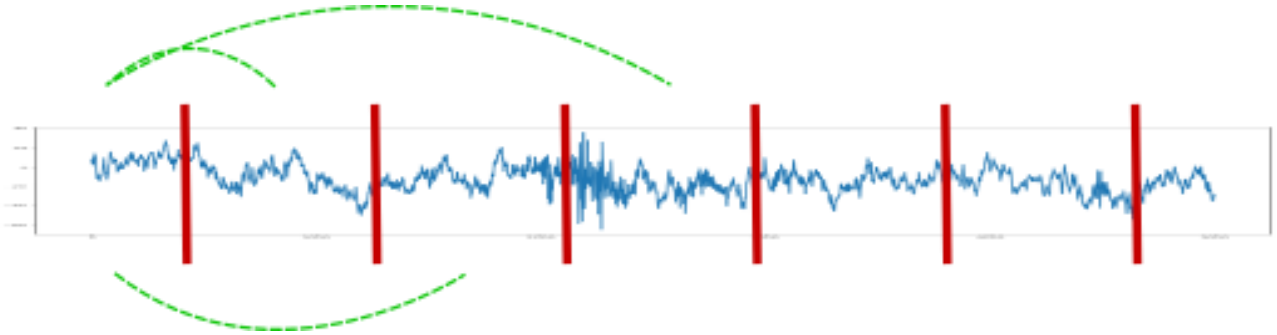
- **Phase Lag Index (PLI)**

$$PLI_{xy} = \left| \frac{1}{N} \sum_{t=1}^{N} sgn(imag(S_{txy}) \right|$$

- **Cross-spectral density**

$$S_{txy} = |A_x||A_y|e^{i\theta_x - \theta_y}$$

- Band filter EEGs: Delta (0.5-4hz), Theta (4-8Hz), Alpha (8-12Hz), Beta (12-30Hz), Gamma (30-80Hz)
- Hilbert Transform
- Split the EEGs into 10 segments and apply PLI



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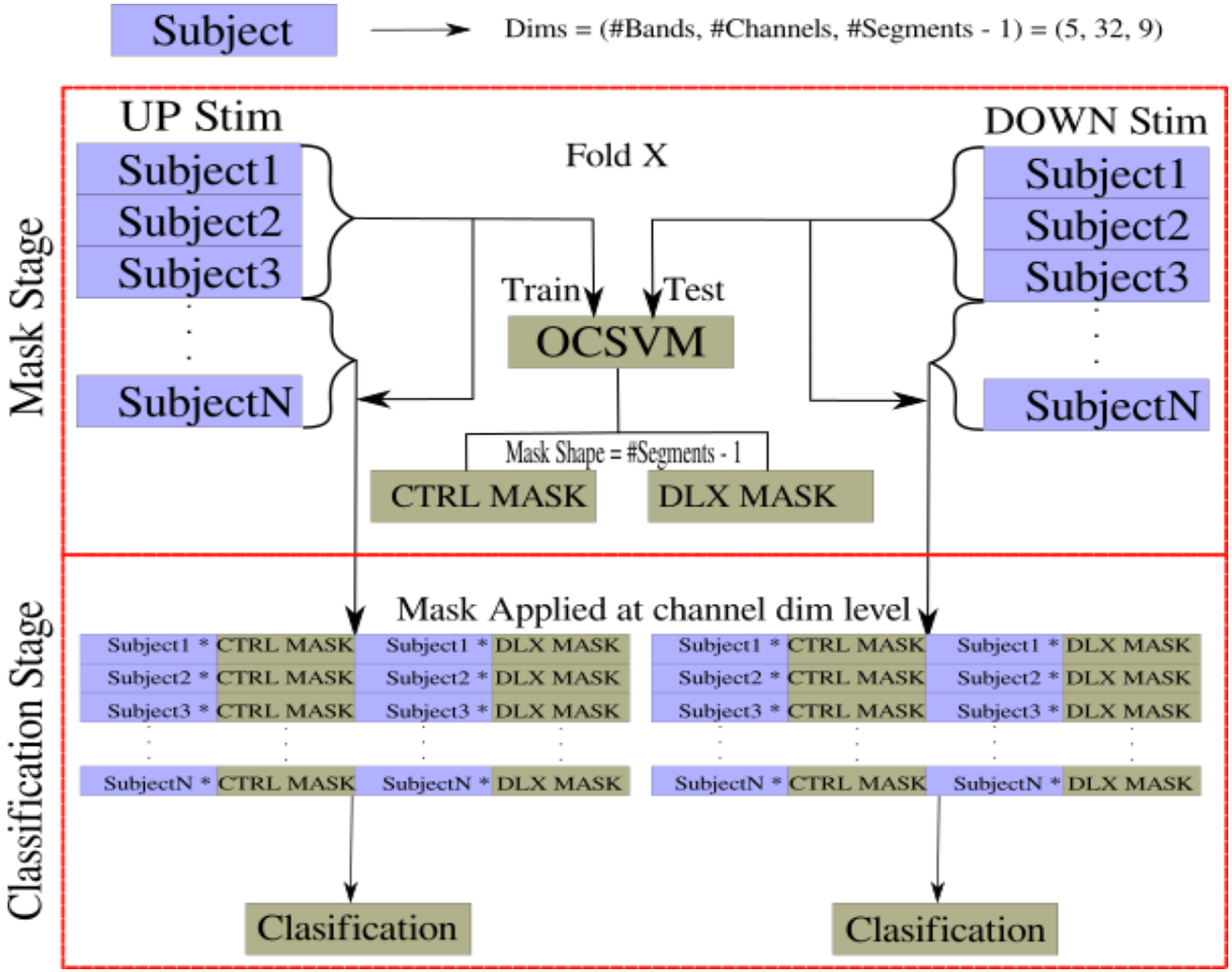

Results

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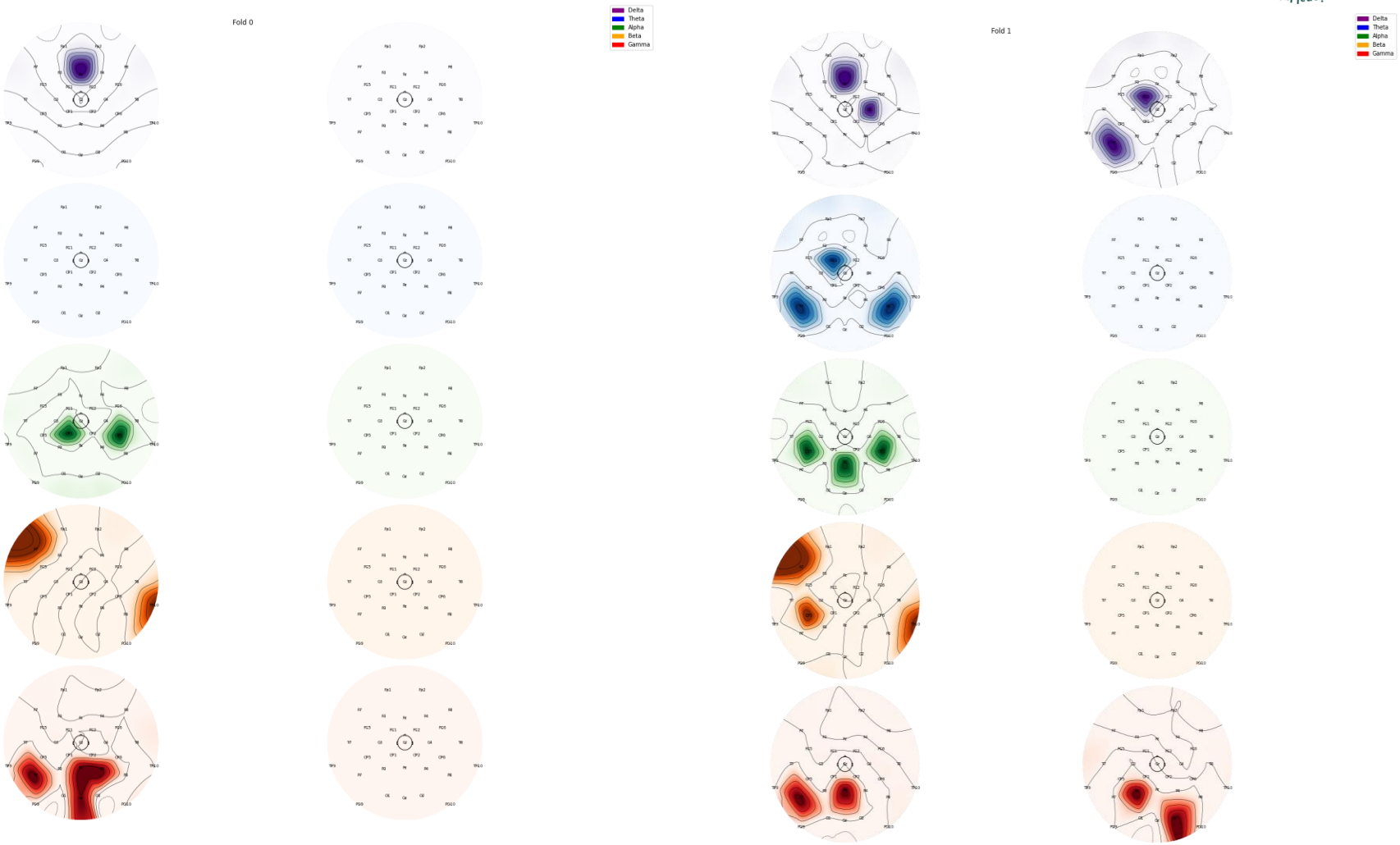

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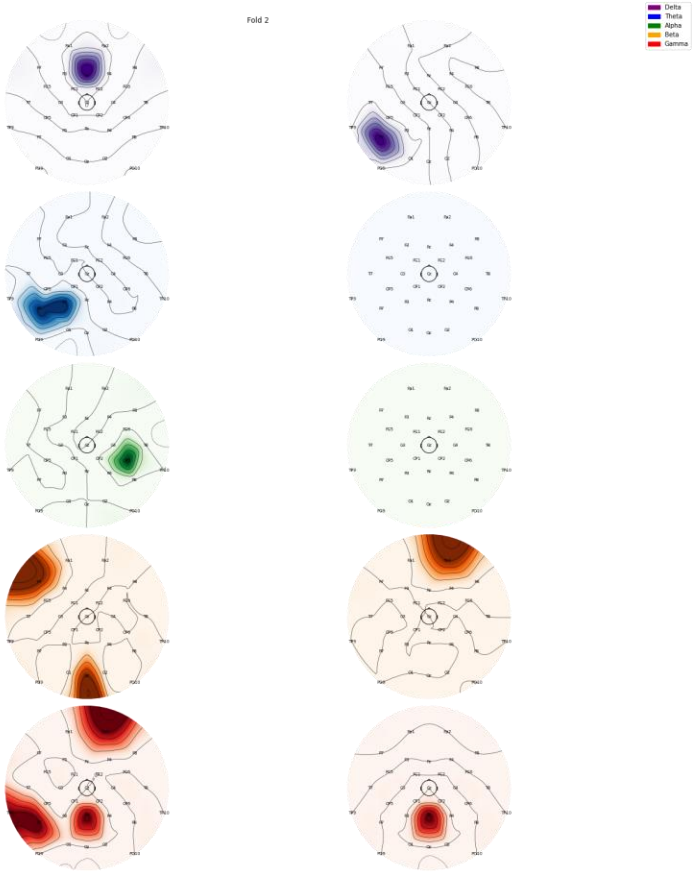

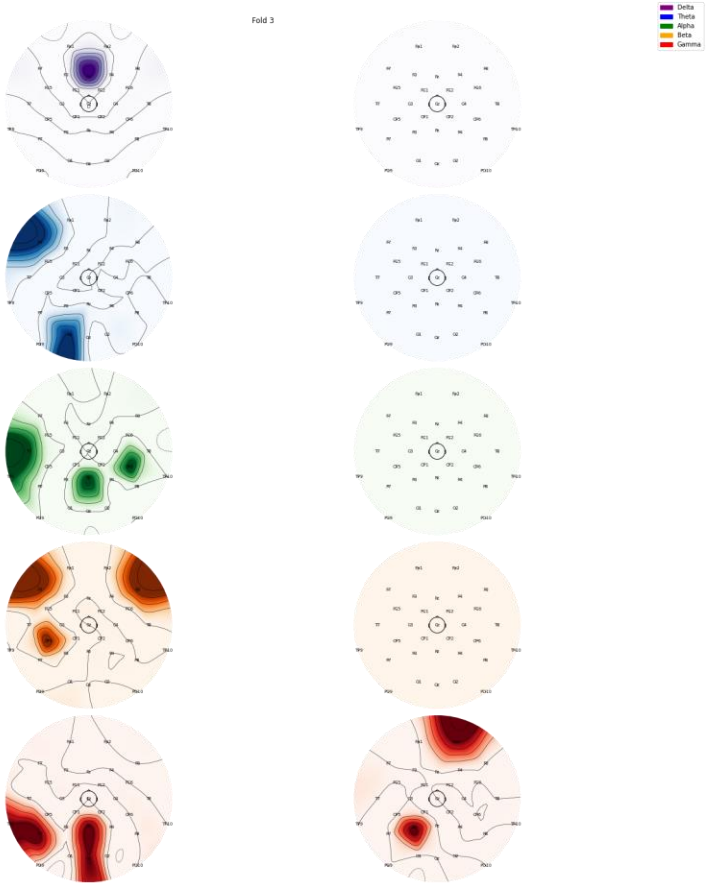

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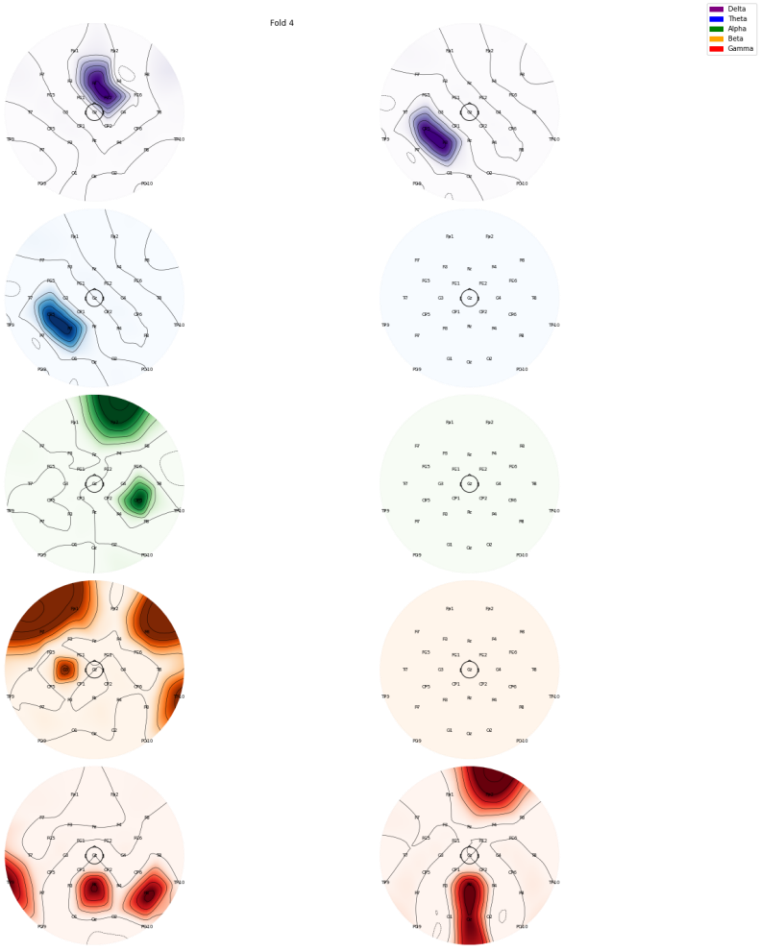

Results

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Band	Classifier	AUC	Sensitivity	Specificity	Accuracy
Alpha	**KNN**	**0.76 ± 0.15**	**0.82 ± 0.15**	**0.76 ± 0.18**	**0.73 ± 0.11**
	SVM	0.71±0.15	0.07±0.13	0.97±0.07	0.71±0.07
Beta	KNN	0.48±0.06	0.20±0.25	0.78±0.25	0.60±0.12
	SVM	0.54±0.13	0.00±0.00	1.00±0.00	0.71±0.05
Delta	KNN	0.50±0.13	0.20±0.27	0.89±0.17	0.69±0.11
	SVM	0.59±0.11	0.00±0.00	1.00±0.00	0.71±0.05
Gamma	KNN	0.66±0.13	0.47±0.45	0.79±0.18	0.67±0.05
	SVM	0.37±0.14	0.20±0.4	0.80±0.4	0.60±0.20
Theta	KNN	0.46±0.09	0.00±0.0	0.91±0.17	0.65±0.11
	SVM	0.54±0.09	0.00±0.00	1.00±0.00	0.71±0.05

Conclusions and Future Work

•We proposed a method to detect differences in how dyslexic children vs non-dyslexic adapt to auditory stimuli.

•Phase Lag Index is used to measure the differences in time and used to build a classification pipeline.

•The results show that the Alpha band carries enough information build a classifier with and AUC up to 0.76

•As a future work, a more intensive exploratory analysis of the rest of the stimuli is planned, as well as try other metrics others than PLI.