EEG & fNIRS Based Alzheimer's Disease Detection

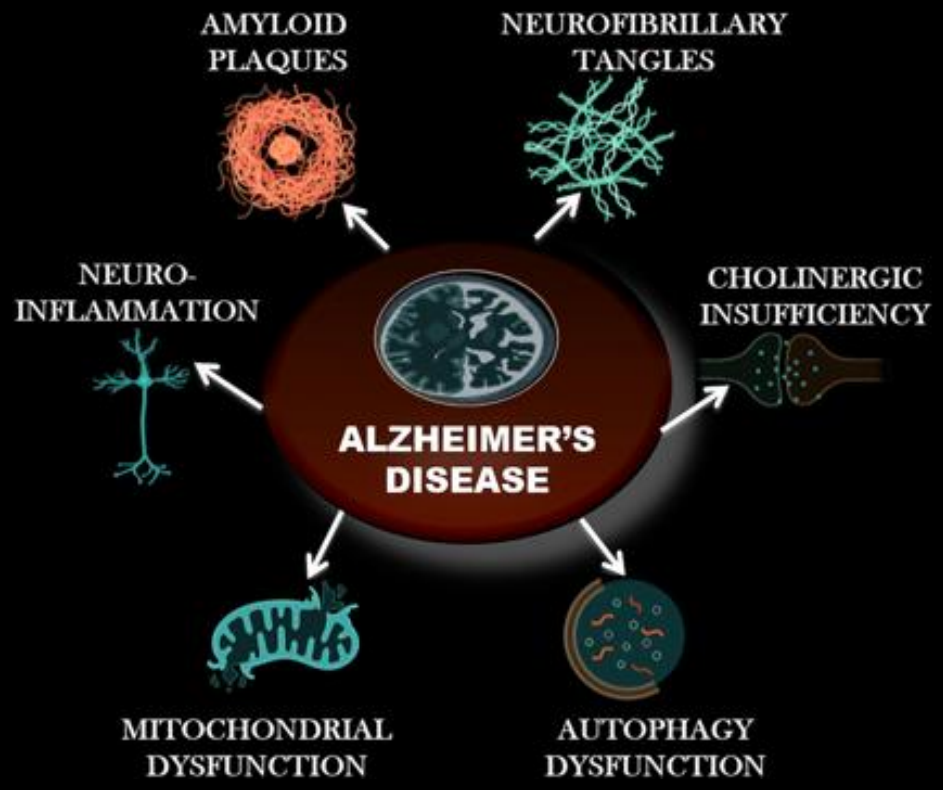
Primarily references the literature: *Event-specific EEG-FNIRS feature fusion FOR Alzheimer's disease classification*[1]

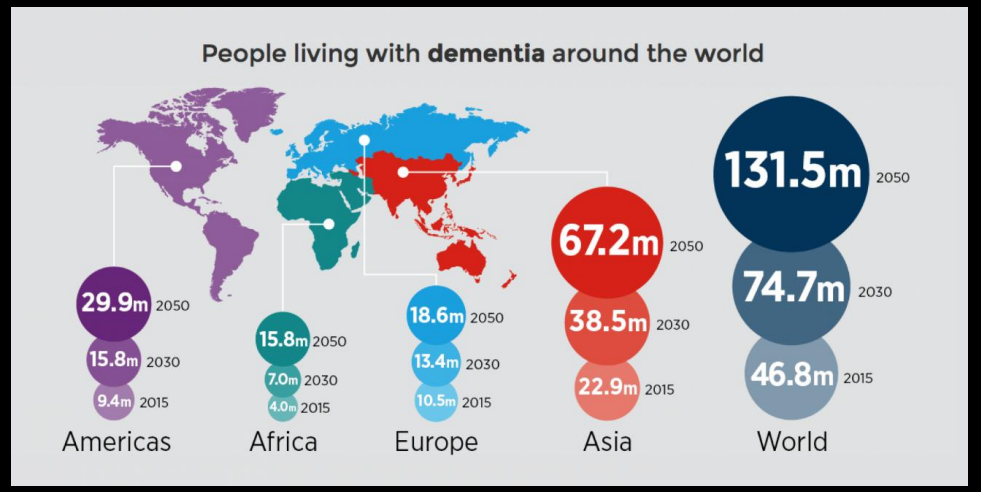
Gangfeng Hu, Sangdae Nam, Niko Hams,
Uli Prantz, Eric Ji, Matthew Zhou

[1] S.-H. Kim, T.-M. Choi, S.-K. Lee, M. Kim, J. G. Kim, and J.-H. Kim, 'Event-specific EEG-FNIRS feature fusion FOR Alzheimer's disease classification', in 2024 IEEE International Conference on Image Processing (ICIP), Abu Dhabi, United Arab Emirates, 2024, pp. 3137–3143.

Introduction: Alzheimer's Disease

- An irreversible neurodegenerative disease
- Starts slowly and progressively worsens
- 60–70% of cases of all dementia cases.





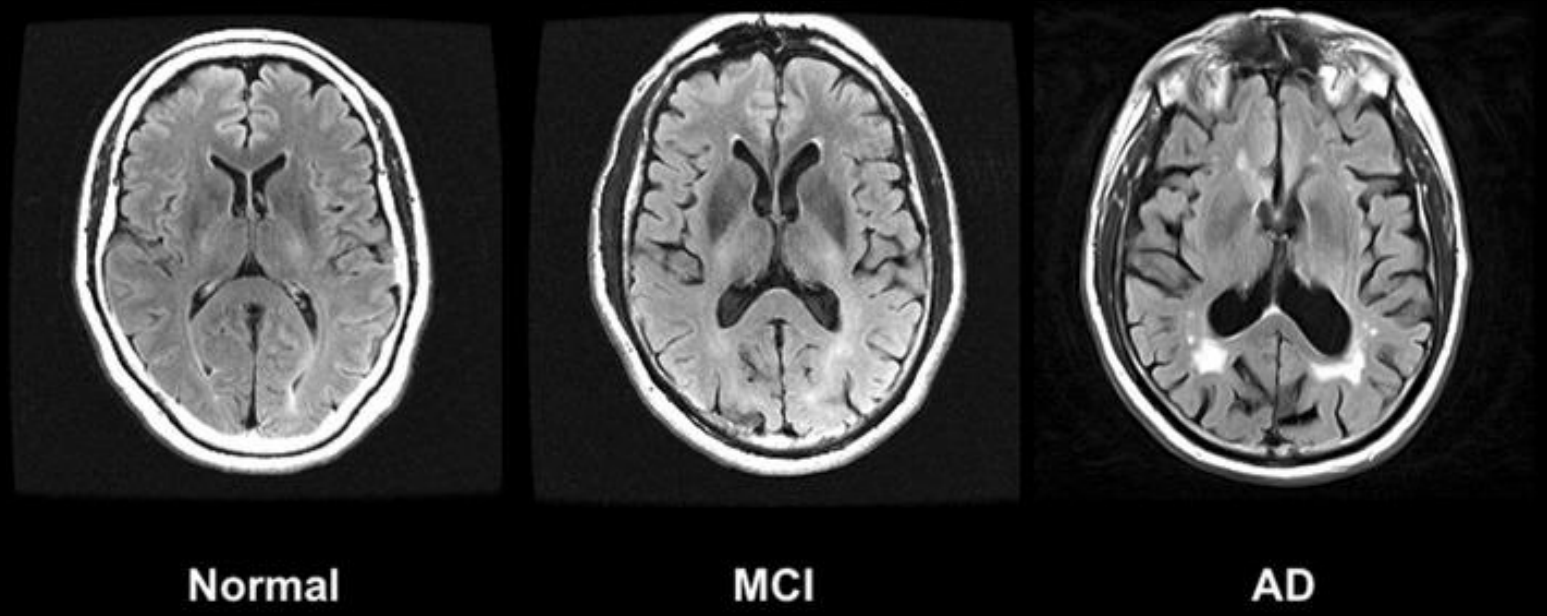
Exact cause is not fully understood:

Some **key factors** believed to be involved:

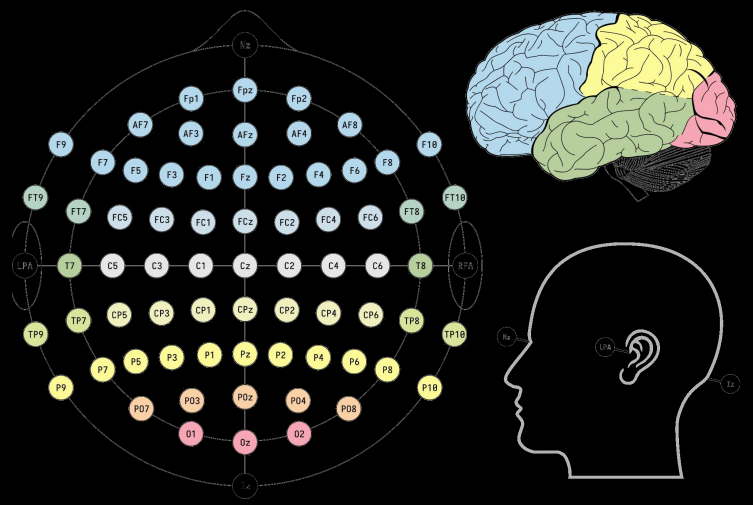
- Genetics
- Abnormal protein deposition: amyloid-β and tau
- Vascular factors
- …

Introduction: Alzheimer's Disease

- **AD** (Alzheimer's Disease): Severe memory and cognitive decline
- **MCI** (Mild Cognitive Impairment): Noticeable but mild cognitive changes
- **NC** (Normal Cognition): Healthy brain function, no impairments
- Focus of Study: Classify participants into these three categories



Introduction: EEG & fNIRS

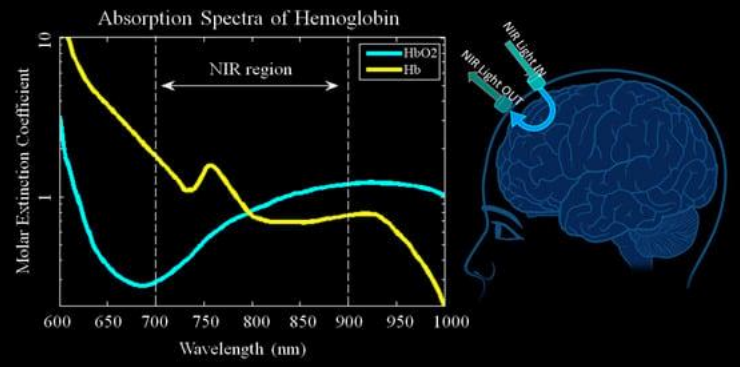


EEG (electroencephalography):

- Non-invasive brain activity recording
- Captures electrical signals in real-time
- High temporal resolution (milliseconds)
- Measures brainwaves: Delta, Theta, Alpha, Beta, Gamma

fNIRS (Functional Near-Infrared Spectroscopy):

- Measures brain blood oxygenation
- Monitors oxygenated (HbO) and deoxygenated hemoglobin (HbR)
- High spatial resolution
- Less sensitive to motion artifacts than EEG



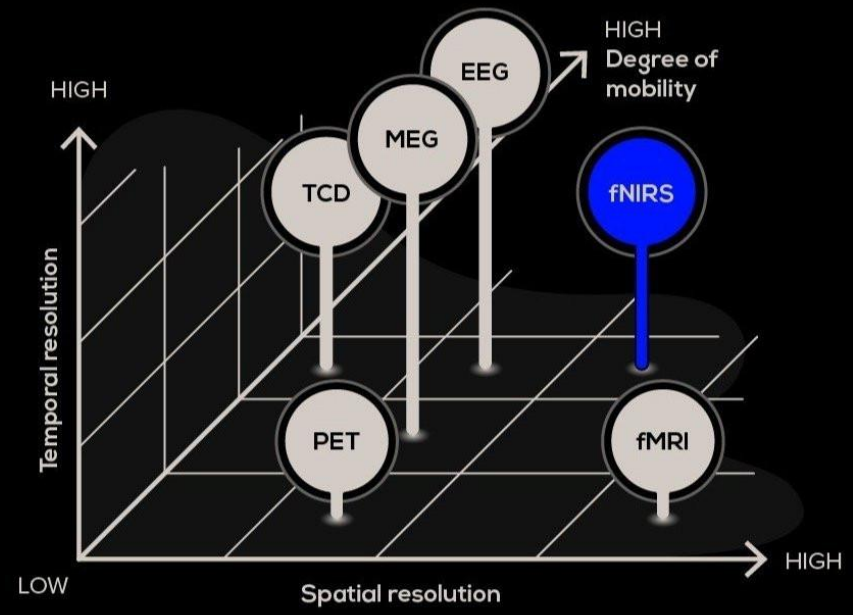
Introduction: EEG & fNIRS

Why Combine EEG and fNIRS?

- Exploit complementary strengths

EEG & fNIRS

EEG	fNIRS
Real-time	Slight delay in response
High temporal	Less motion-sensitive
Less spatial resolution	High spatial resolution



Methods: the Four Tasks

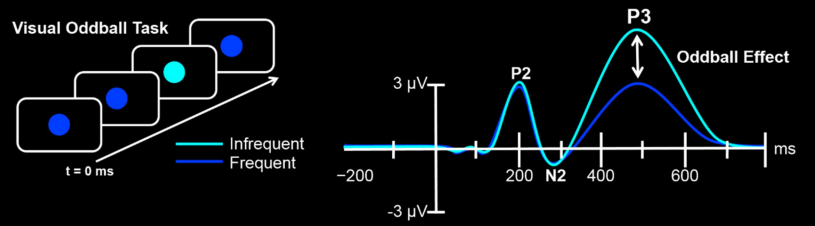
EEG and fNIRS signals are detected during the process of the four tasks below:

1. Resting Task:

- Focus on a white cross on a screen
- Duration: 60 seconds
- Baseline brain activity measurement

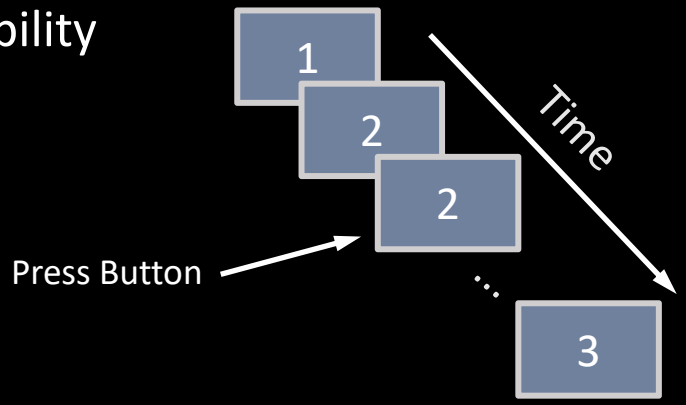
2. Oddball Task:

- Identify yellow (target) and blue (non-target) circles
- Respond to yellow by pressing a button
- Tests attention and response inhibition



3. 1-back Task:

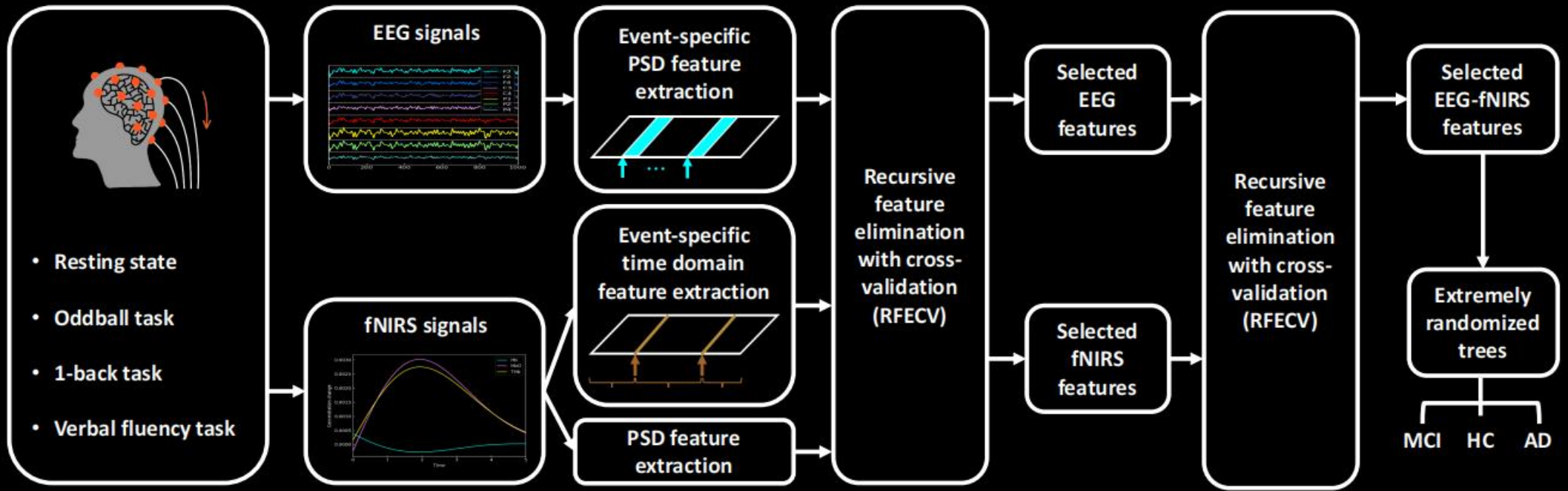
- A number in {1,2,3} shows on a screen every time
- Press a button when the current number matches the previous one
- Evaluates working memory and cognitive flexibility



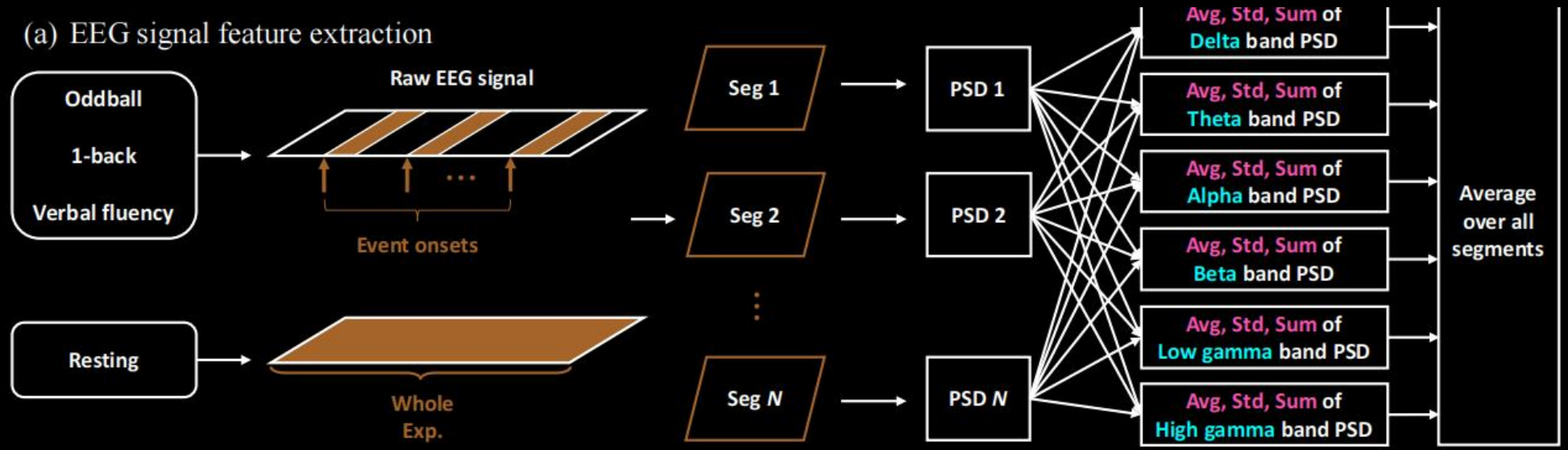
4. Verbal Fluency Task:

- **Phonemic Fluency:** Generate words starting with a given letter
- **Semantic Fluency:** Generate words within a specific category (e.g., animals)

Methods: Pipeline

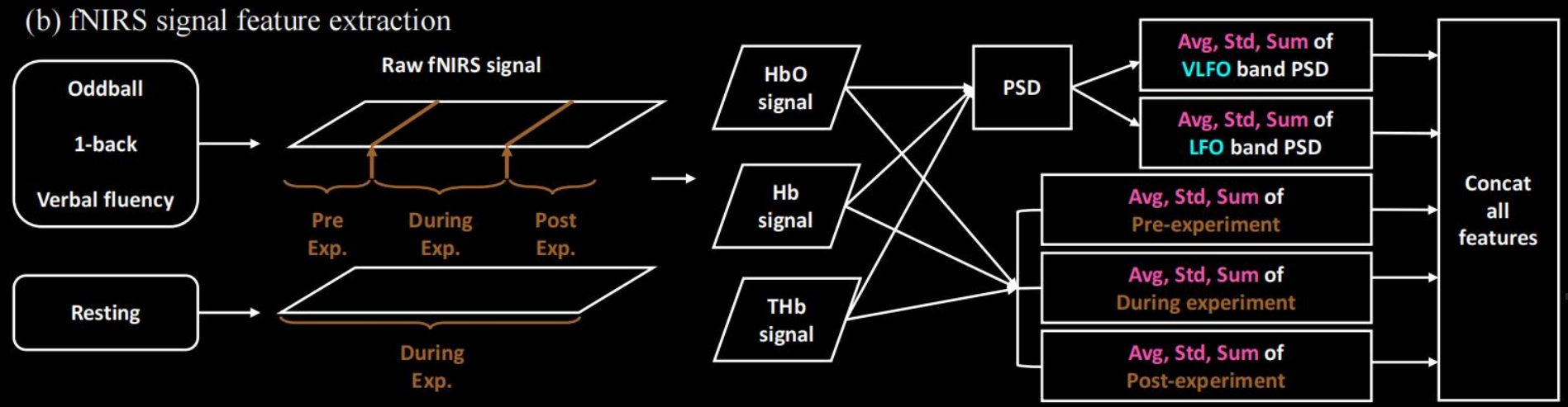


Methods: Feature Extracion



PSD (Power Spectral Density, W/Hz or dB/Hz): for a certain segmented signal $x(t)$, let $X(f)$ be its Fourier transform: then the PSD of the signal is

$$P(f) = |X(f)|^2$$



Experiment Results

Performance Metrics:

Metric	ExtraTree	MLP
Accuracy	0.79	0.83
Macro Avg F1	0.80	0.83
Weighted Avg F1	0.79	0.83

Key Observations

- MLP performs slightly better in overall accuracy and F1 scores.
- ExtraTree excels in precision for Class 0 but has lower recall for Class 2.
- MLP balances recall better across classes, leading to higher overall performance.