

Towards Reliable EEG Signatures of Parkinson's Disease: Converging Evidence from Rest and Task

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Introduction

- Parkinson's Disease (PD) affects 10 million people worldwide as the fastest growing neurodegenerative disease.¹
 - Diagnosis is complicated and often late in the disease process, preventing crucial early intervention.^{2,3}
- Apathy is a non-motor symptom of PD, associated with deficits in goal-directed behaviour. It is a major determinant of reduced quality of life.⁴
 - It also affects decision-making. To counter this, non-apathetic patients might use a compensatory thalamo-cortical brain network to aid value-based learning.⁵

We know that:

- Resting-state EEG activity in PD patients is altered.⁶
 - Apathy-related deficits are only characterized by MRI, missing out on the temporal resolution of EEG.⁵
 - EEG is non-invasive, widely available in hospitals, and inexpensive.
- Therefore...

EEG is a promising candidate for unveiling novel signatures of Parkinson's Disease in both rest and decision-making.

Methods

Participants

N = 49;
PD = 31 (11 f, M_{age}=63.8; SD=6.8)
HC = 18 (7 f, M_{age}=63.7; SD=7.5)
11 apathetic (LARS score)

Brain Imaging

32 chan
mBrainTrain EEG system
250 Hz sampling rate

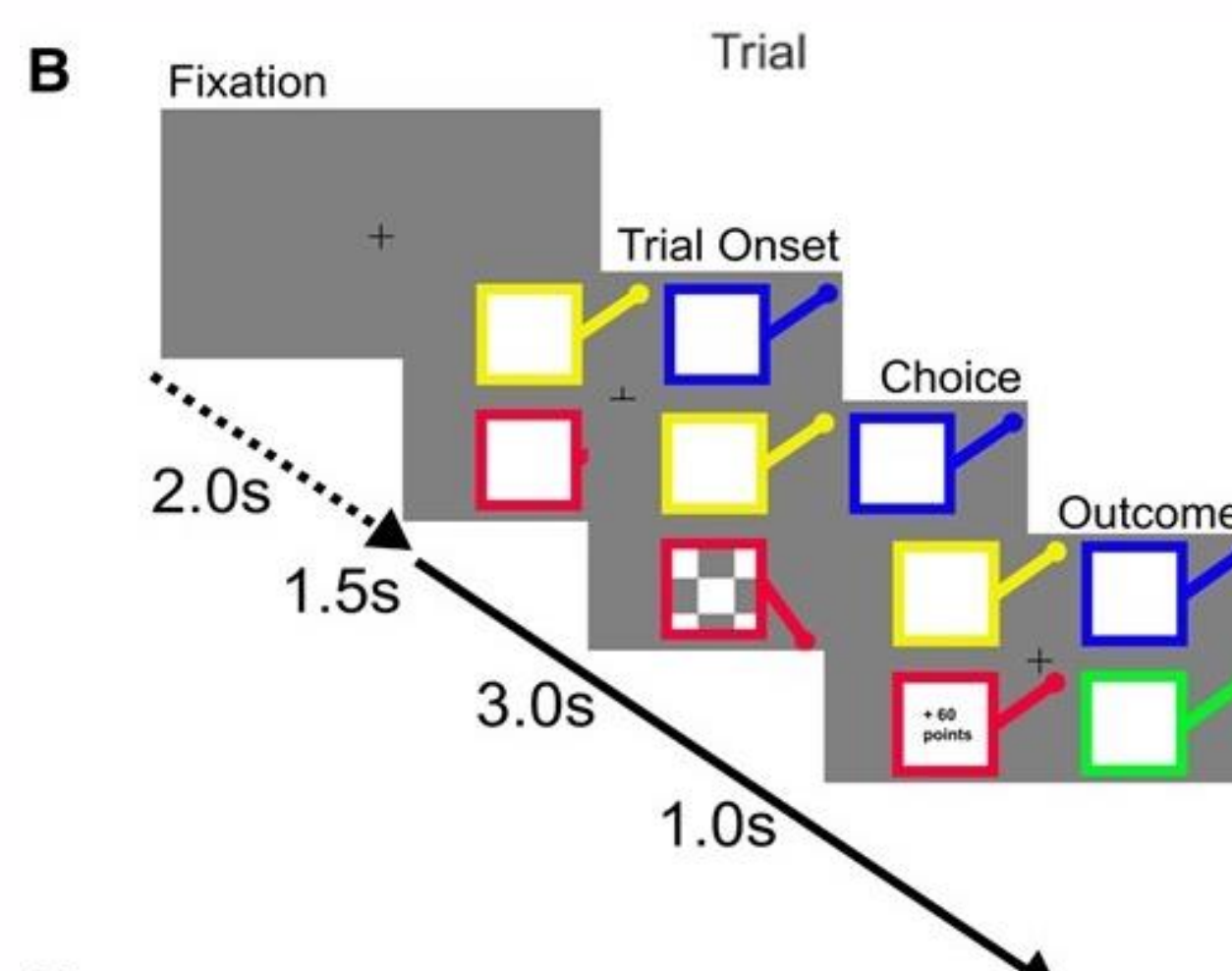
- Resting State:** 5 min, Eyes Closed
- Four-Armed Bandit task⁷** (Fig.1)

Task⁷



Figure 1

Four-armed Bandit Task



Analysis

Preprocessing → filtering, removing bad chans, removing bad epochs, ICA

Resting State:
Fourier Transform & Aperiodic (1/f) analysis
T-test to compare HC & PD

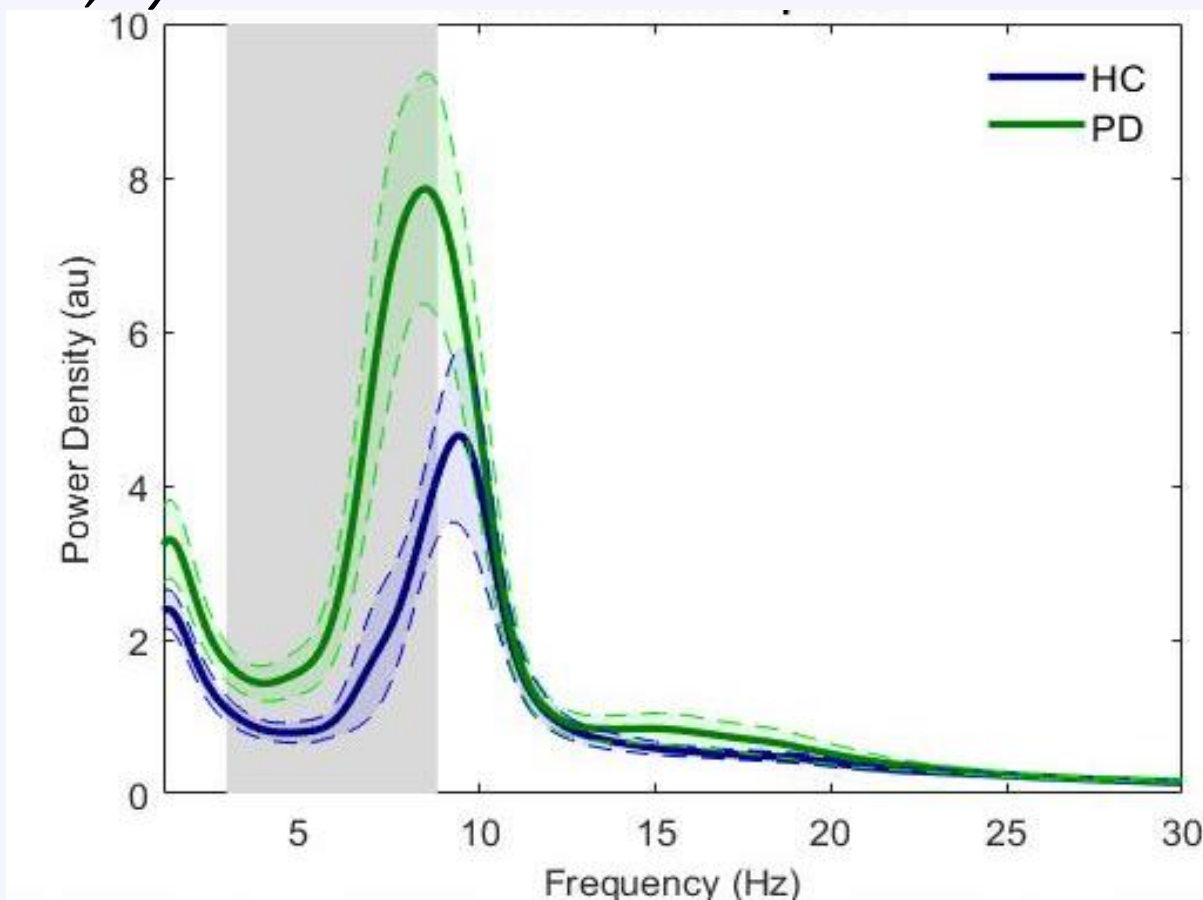
Task:
Fourier Transform & Time-Freq analysis
Beh regression:

$$\text{Power}_{\text{trial}} = \beta_0 + \beta_1(\text{RT}) + \beta_2(\text{trialNo}) + \beta_3(\text{stay}) + \epsilon$$

Results

Findings in Resting State EEG

Spectral power differences between PD and HC in RS, eyes closed



Power differences

PD patients show significant power increase in the theta/low alpha range (shaded area = p<.05) as opposed to HCs.

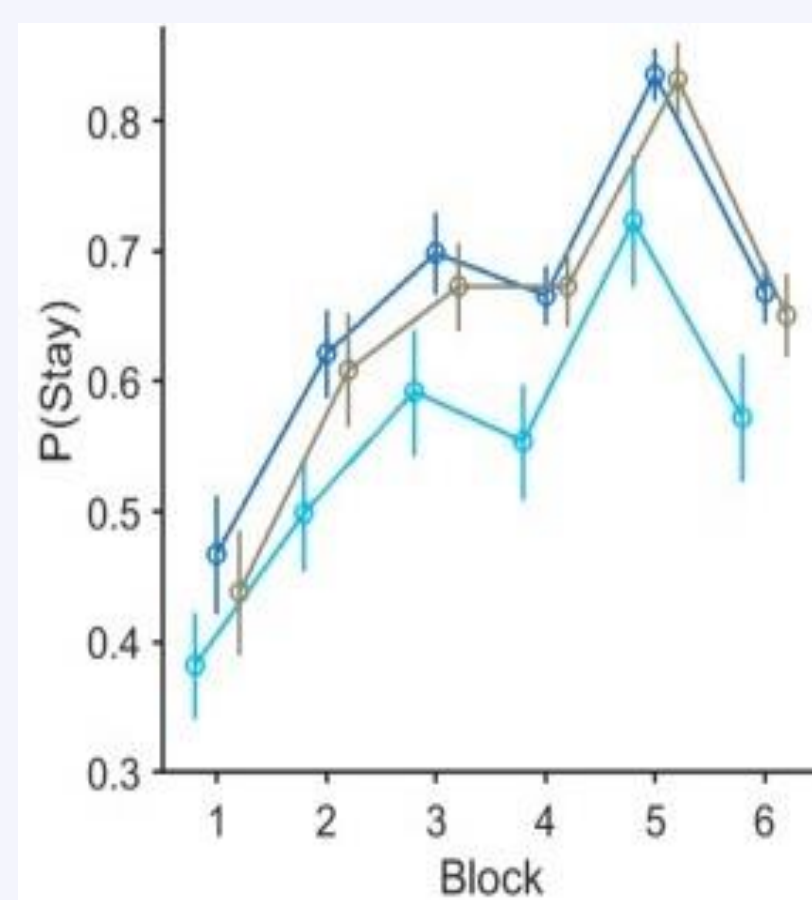
Aperiodic (1/f) analysis

Disentangling aperiodic and periodic differences reveals the difference is a slowing of peak frequency (alpha).

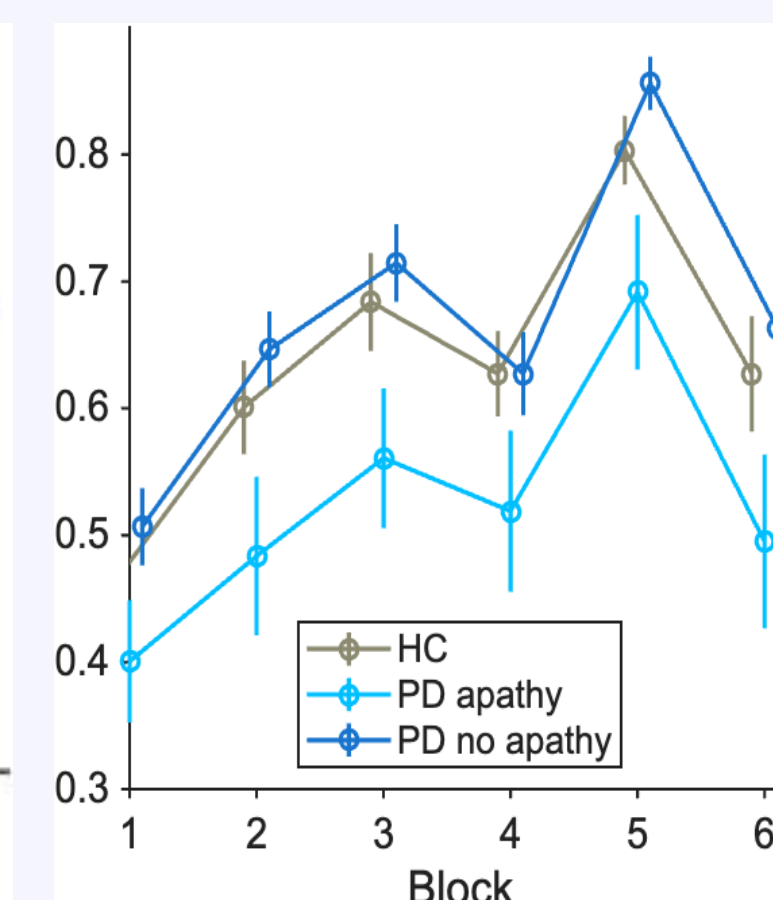
Novel prelim finding: alpha peak slowing in PD is significantly correlated with apathy score.

Findings in Task Behaviour

Probability of Staying by block in Gilmour et al. 2024



Probability of Staying by block in current study



P(stay)

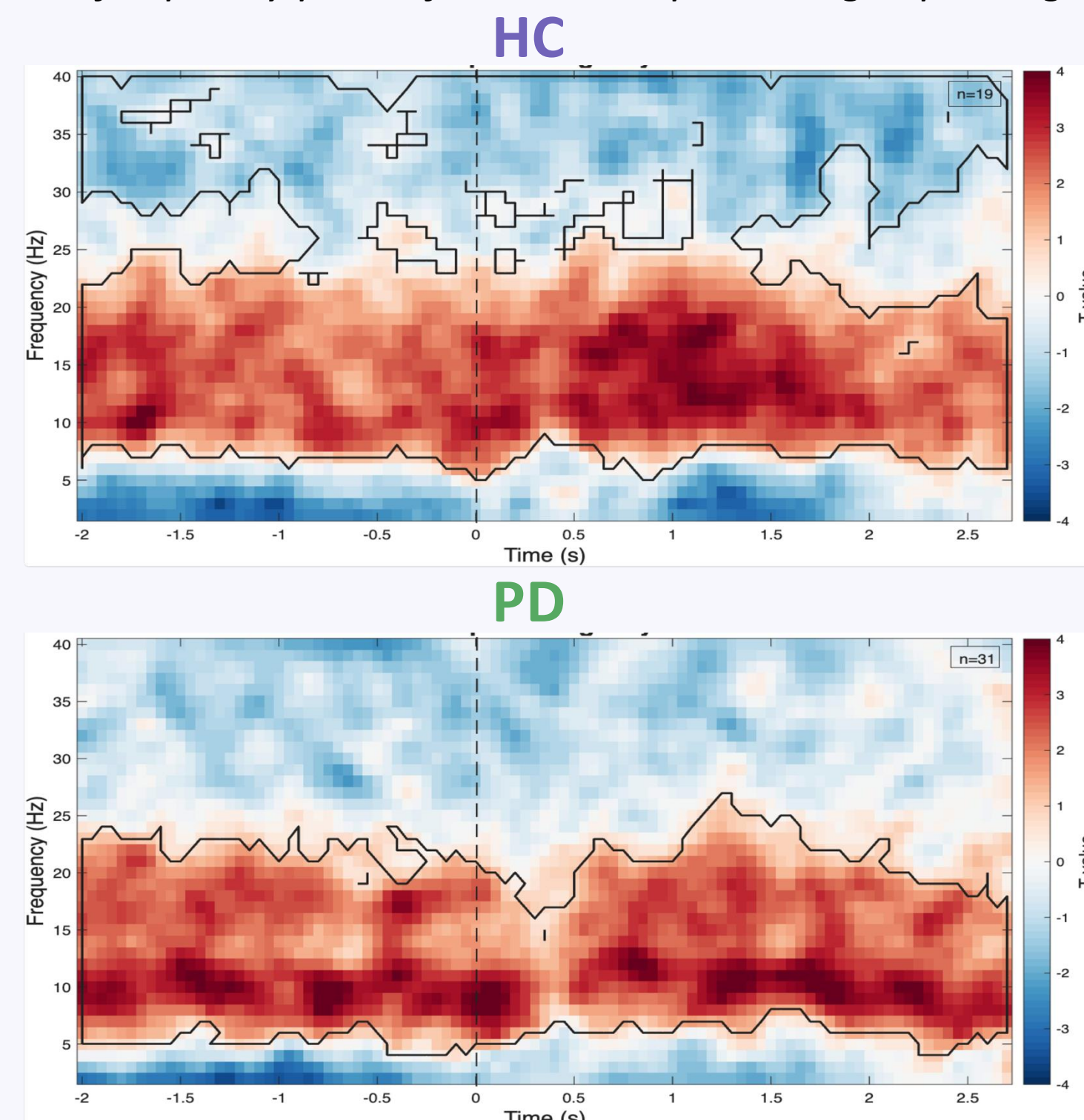
The present study replicates results from Gilmour et al. (2024).

PD without apathy, just like HCs, exploit (stay) more.

Apathetic PD explore more.

Time-frequency plots of EEG Power predicting Exploiting by group

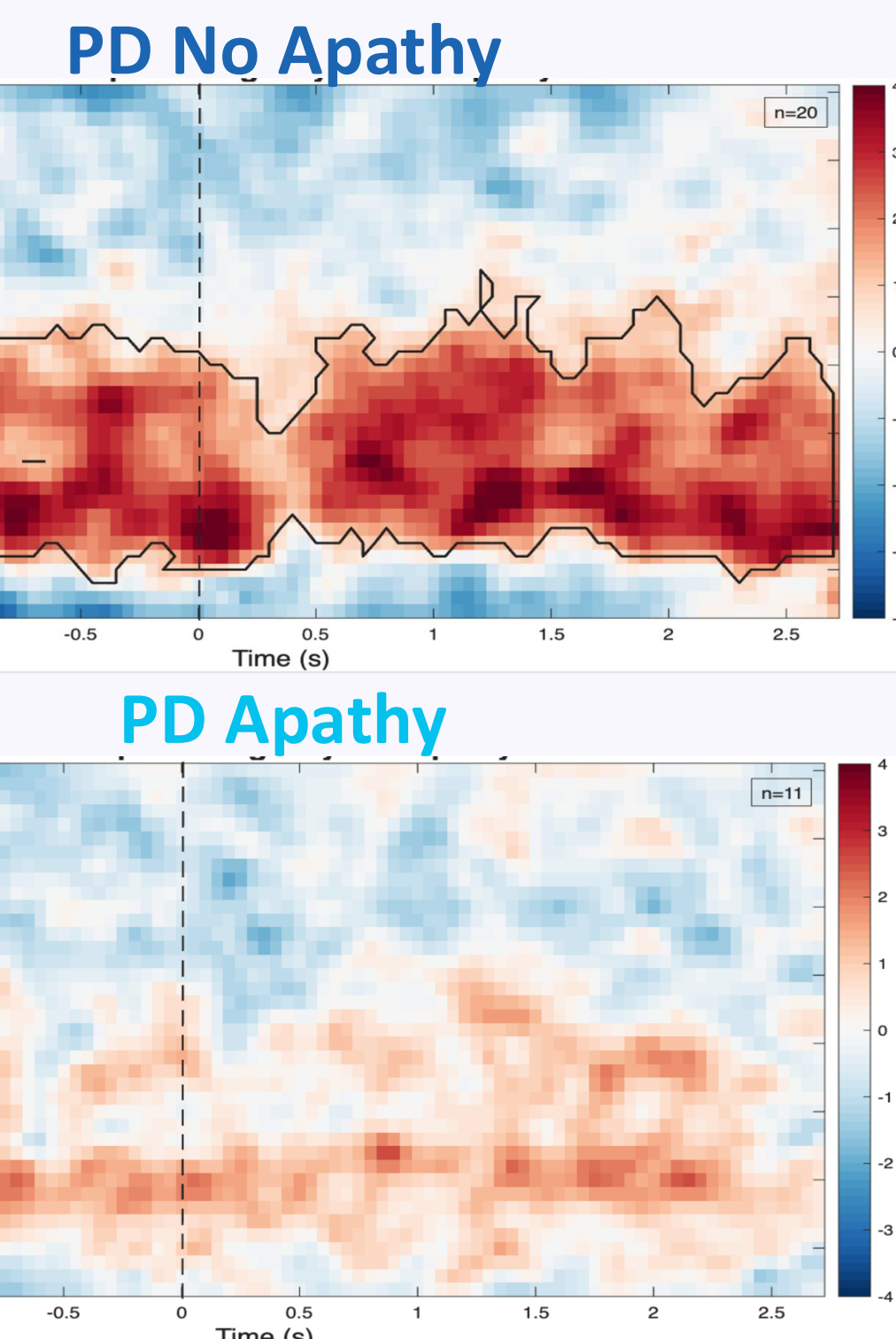
Findings in Task EEG



Exploit (stay) decisions in HCs are predicted by power increase in high alpha/beta and decrease in low gamma.

A similar increase, but in lower frequencies predicts exploit (stay) decisions in PD.

This is the EEG signature of deciding to stick with the same choice.



Apathy vs No Apathy

The lower frequency signal predicting exploit (stay) remains significant for the non-apathetic group.

However, it is vastly reduced in the apathetic group, reflecting their more explorative behaviour.

EEG signature of disrupted exploit-related neural mechanism?

Discussion

- Alterations in EEG are evident in both resting-state and task-based conditions in Parkinson's Disease (PD).
- Notably, these changes are associated with non-motor symptoms, particularly apathy.
- Only motor symptoms of PD are currently treatable through procedures such as deep brain stimulation (DBS) and MR-guided ultrasound.
- Our findings shed light on neural mechanisms of apathy in PD, showing potential for future therapeutic targets for apathy.

References

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