Biomarkers of Sleep & Sleep Disturbance: Methods and Solutions

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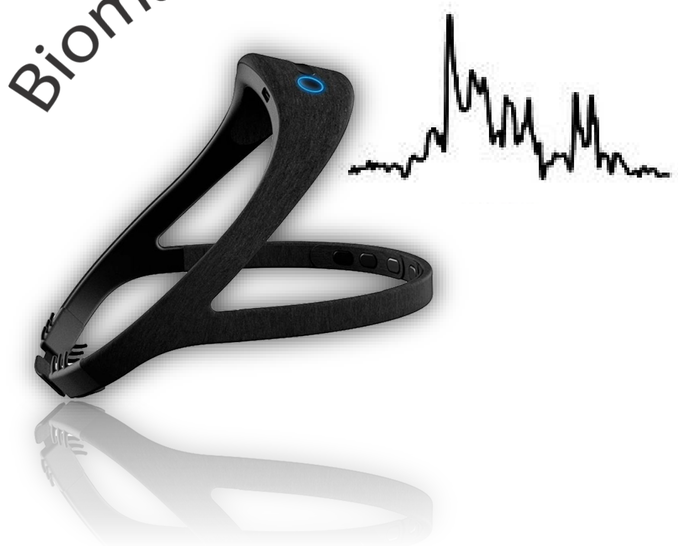
1.

Biomarkers



1.

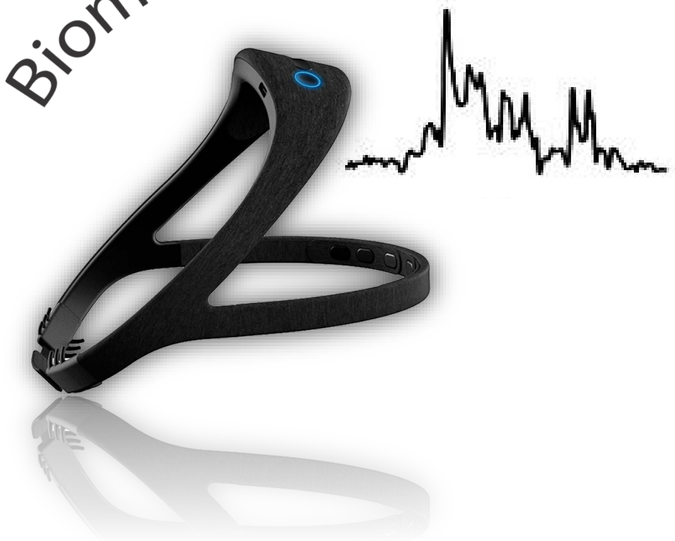
Biomarkers

2.

Mitigation

1.

Biomarkers

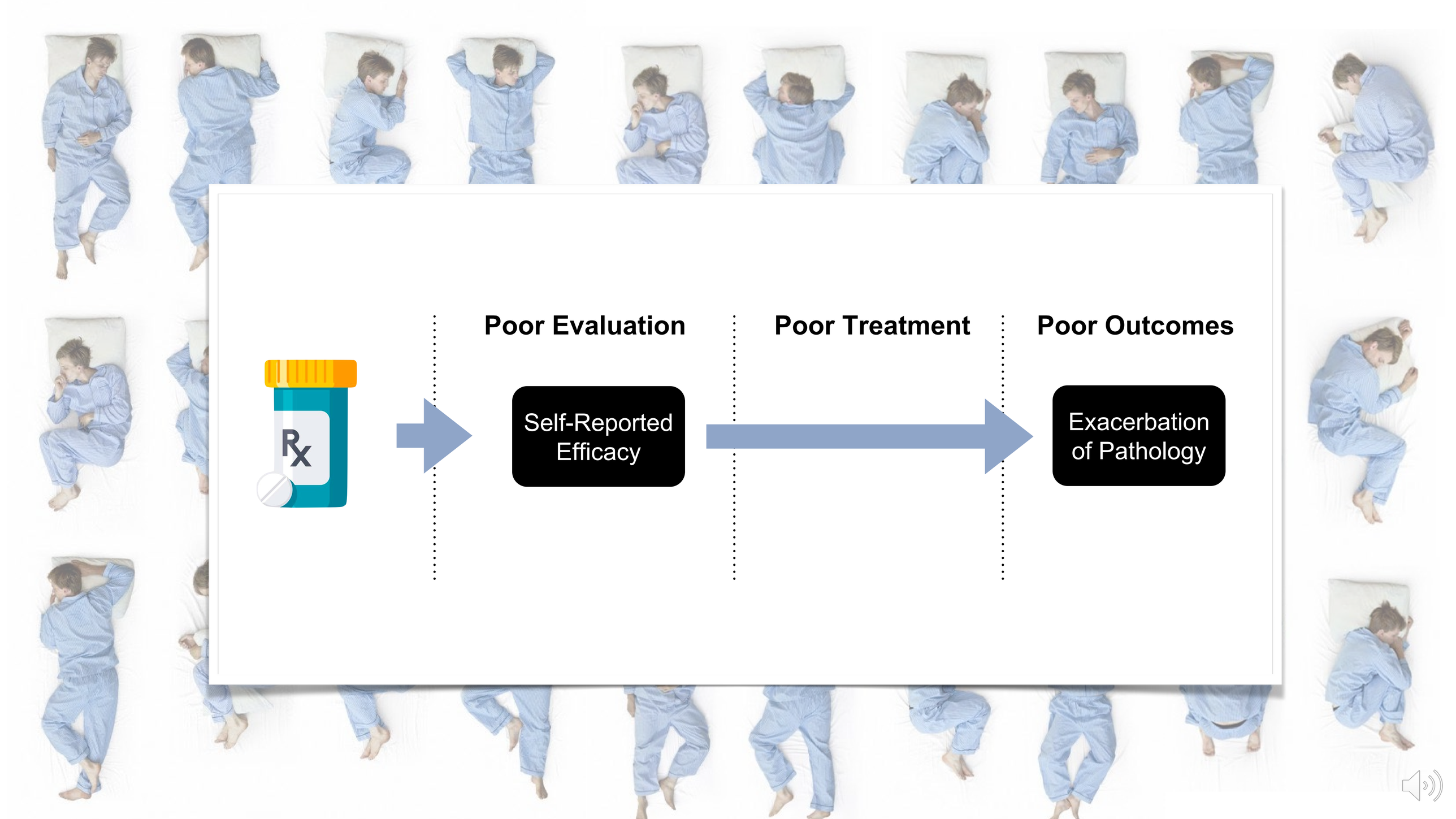


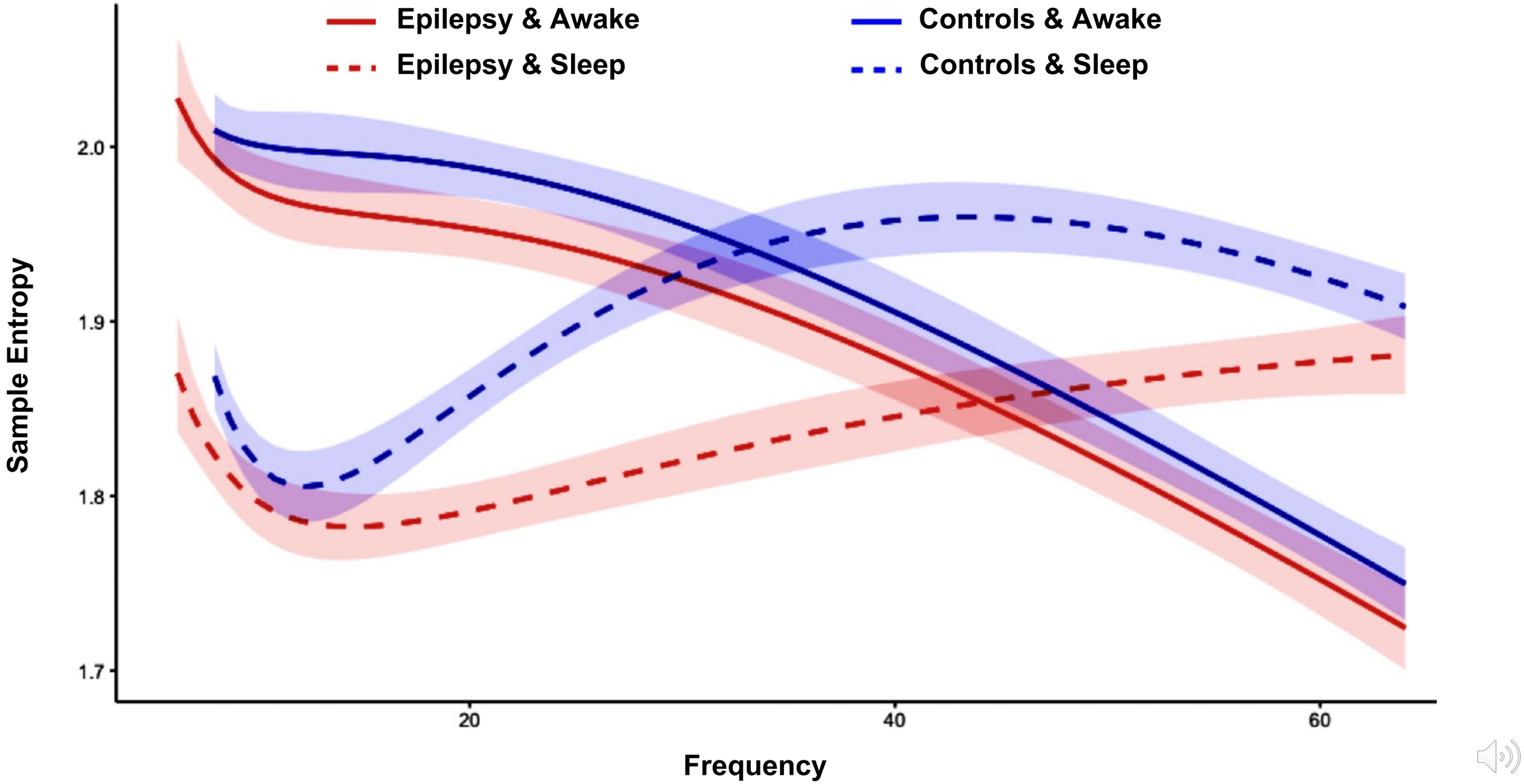
2.

Mitigation

3.

Collaboration


Poor Evaluation
Poor Treatment
Poor Outcomes
Rx
Self-Reported Efficacy
Exacerbation of Pathology

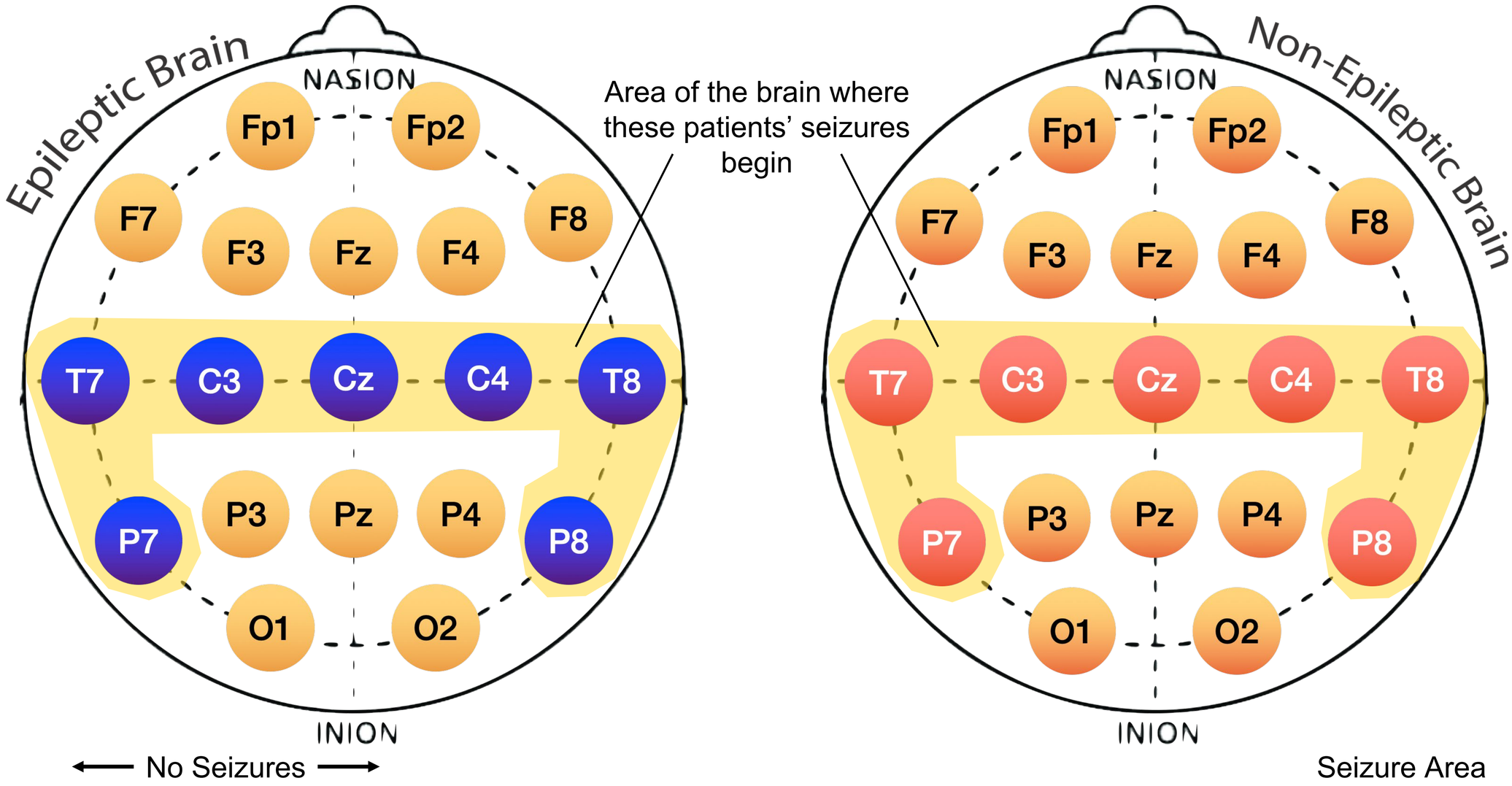

Epilepsy & Awake
Epilepsy & Sleep
Controls & Awake
Controls & Sleep
Sample Entropy
2.0
1.9
1.8
1.7
20
40
60
Frequency

Model

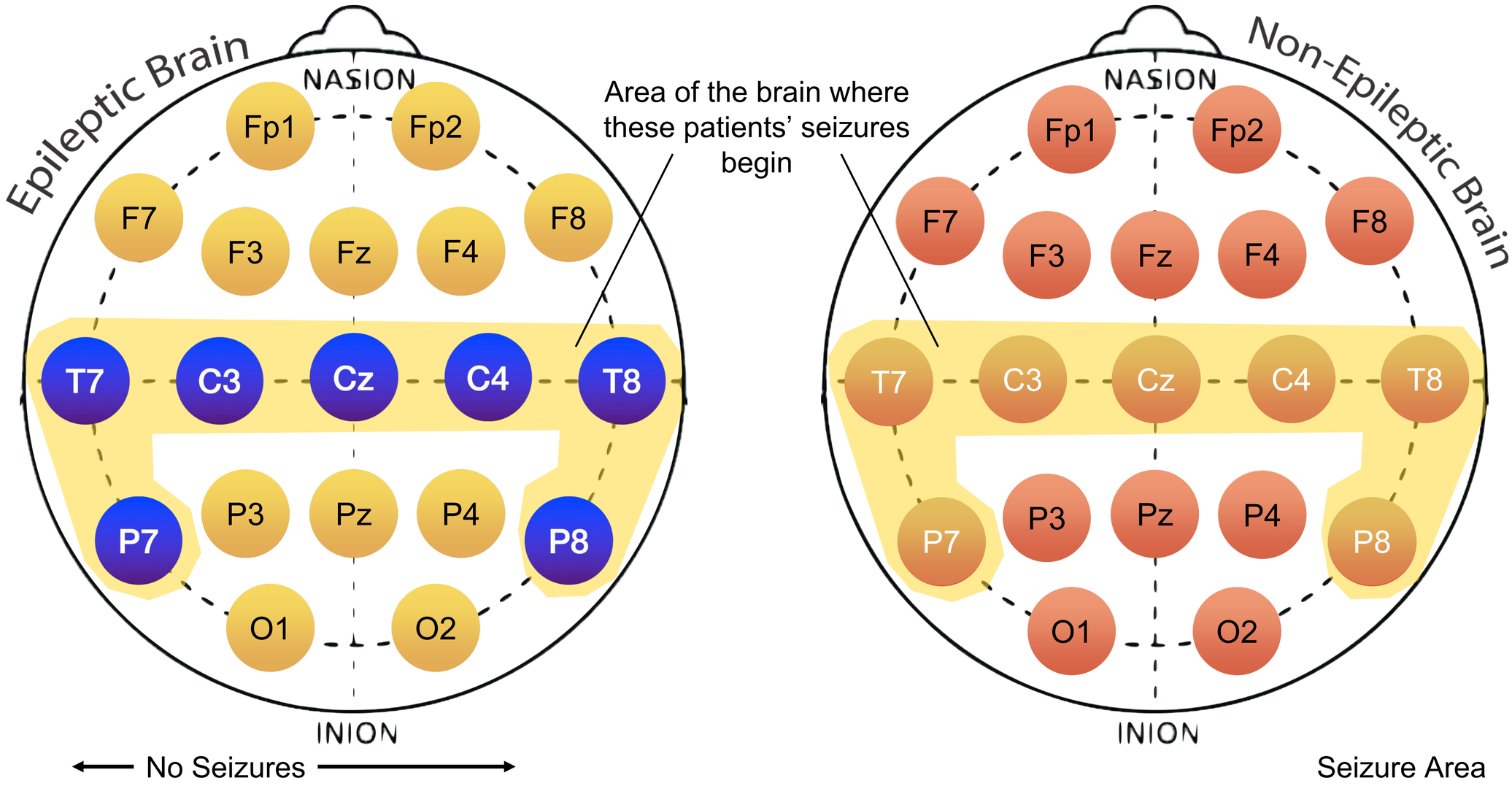
Medication Effective at Reducing Epileptogenicity

Medication NOT Effective at Reducing Epileptogenicity

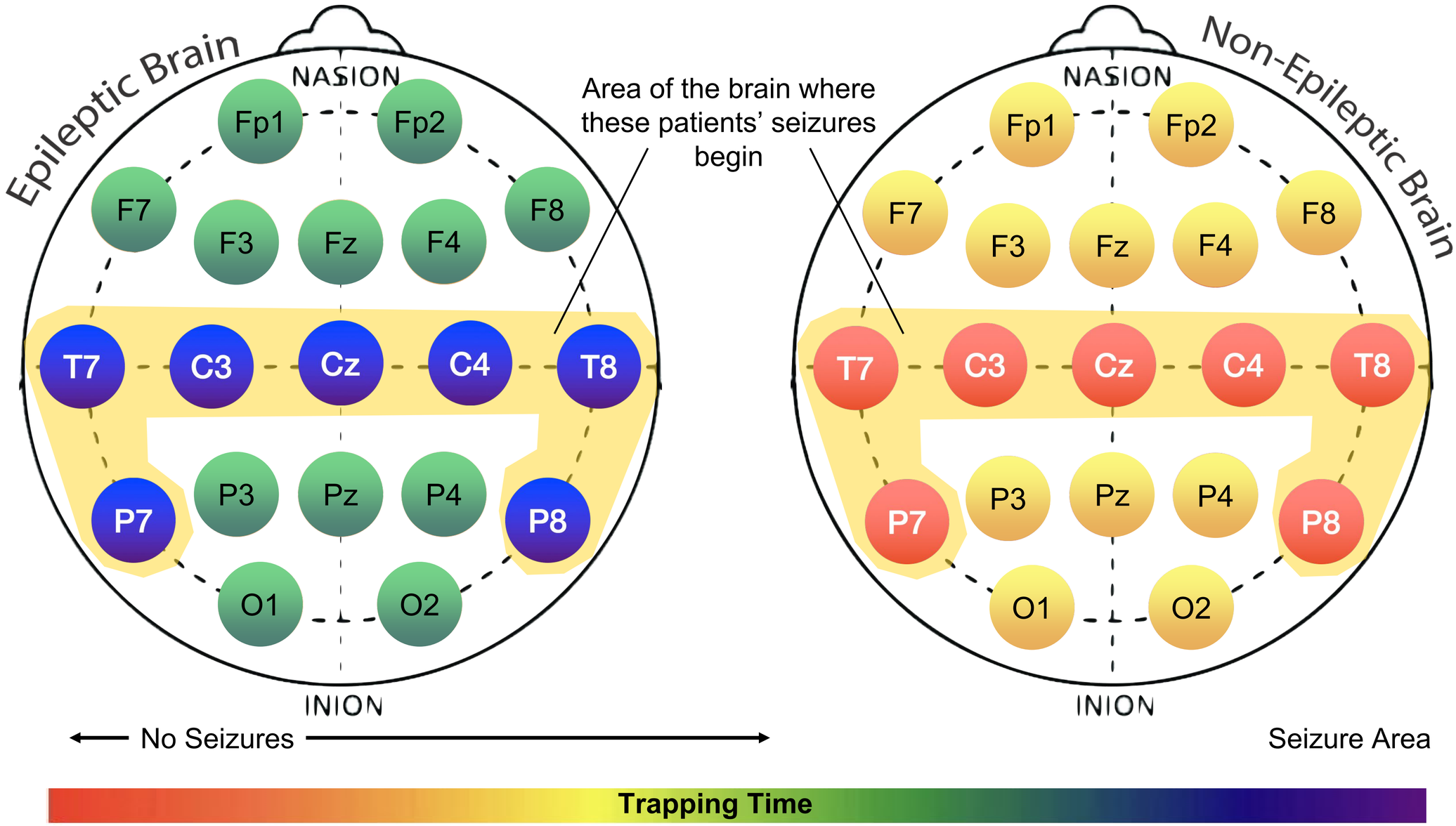
Digital Biomarkers of Complexity
Sample Entropy



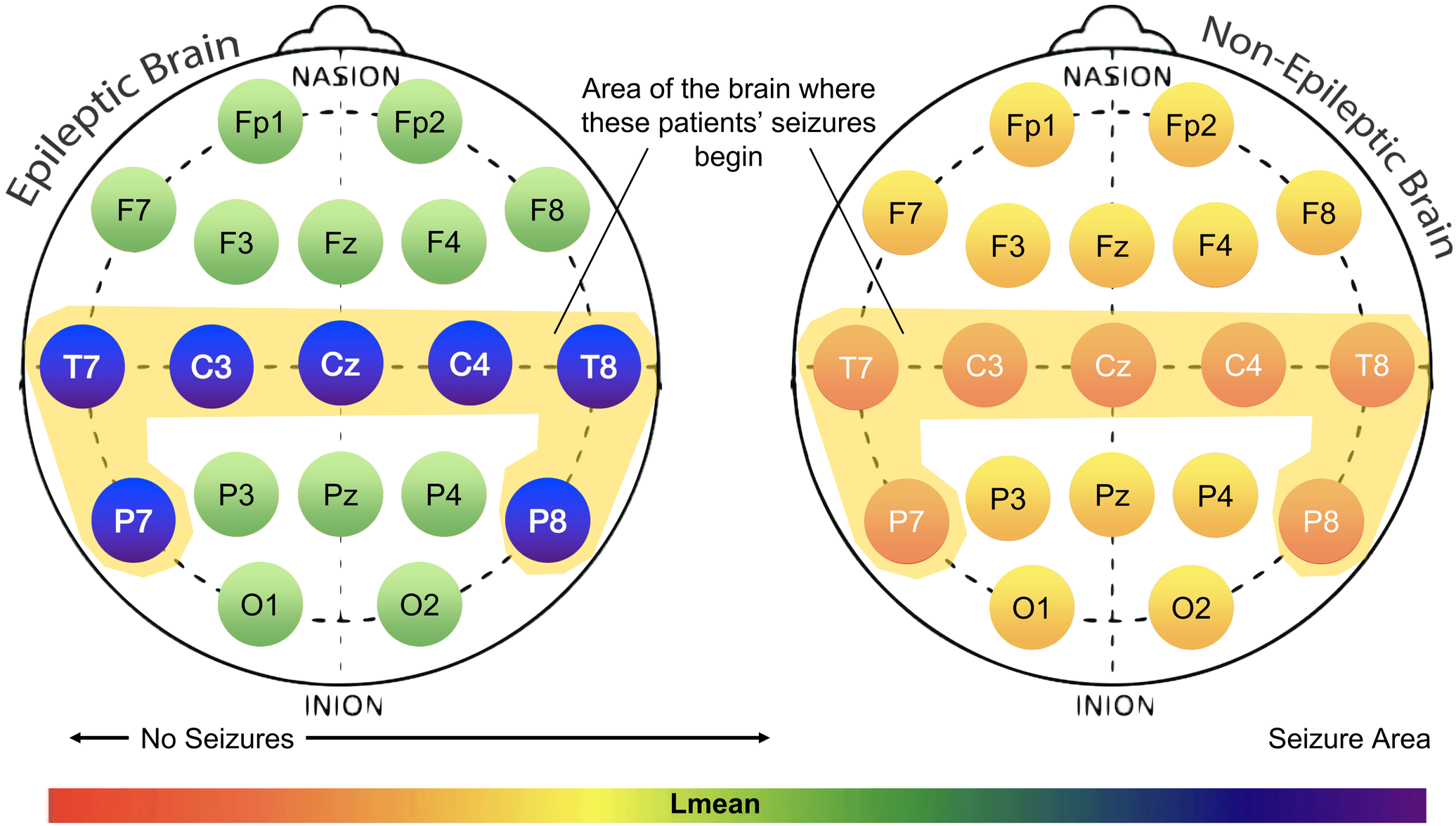
Digital Biomarkers of Complexity
Lmax (max line length in RQA diagram)



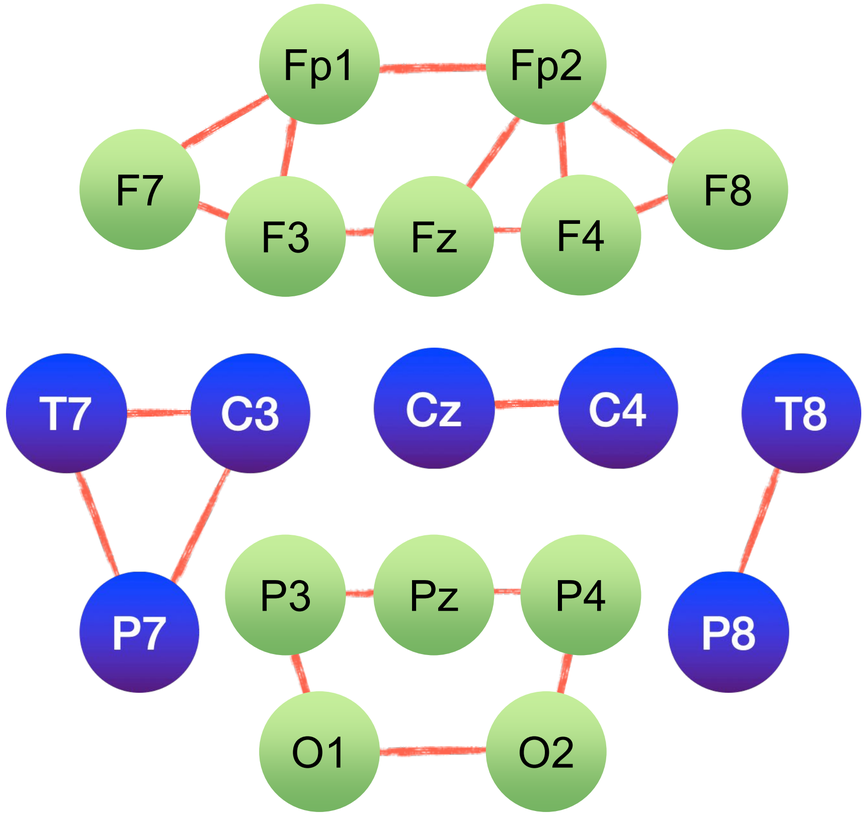
Digital Biomarkers of Complexity
Trapping Time

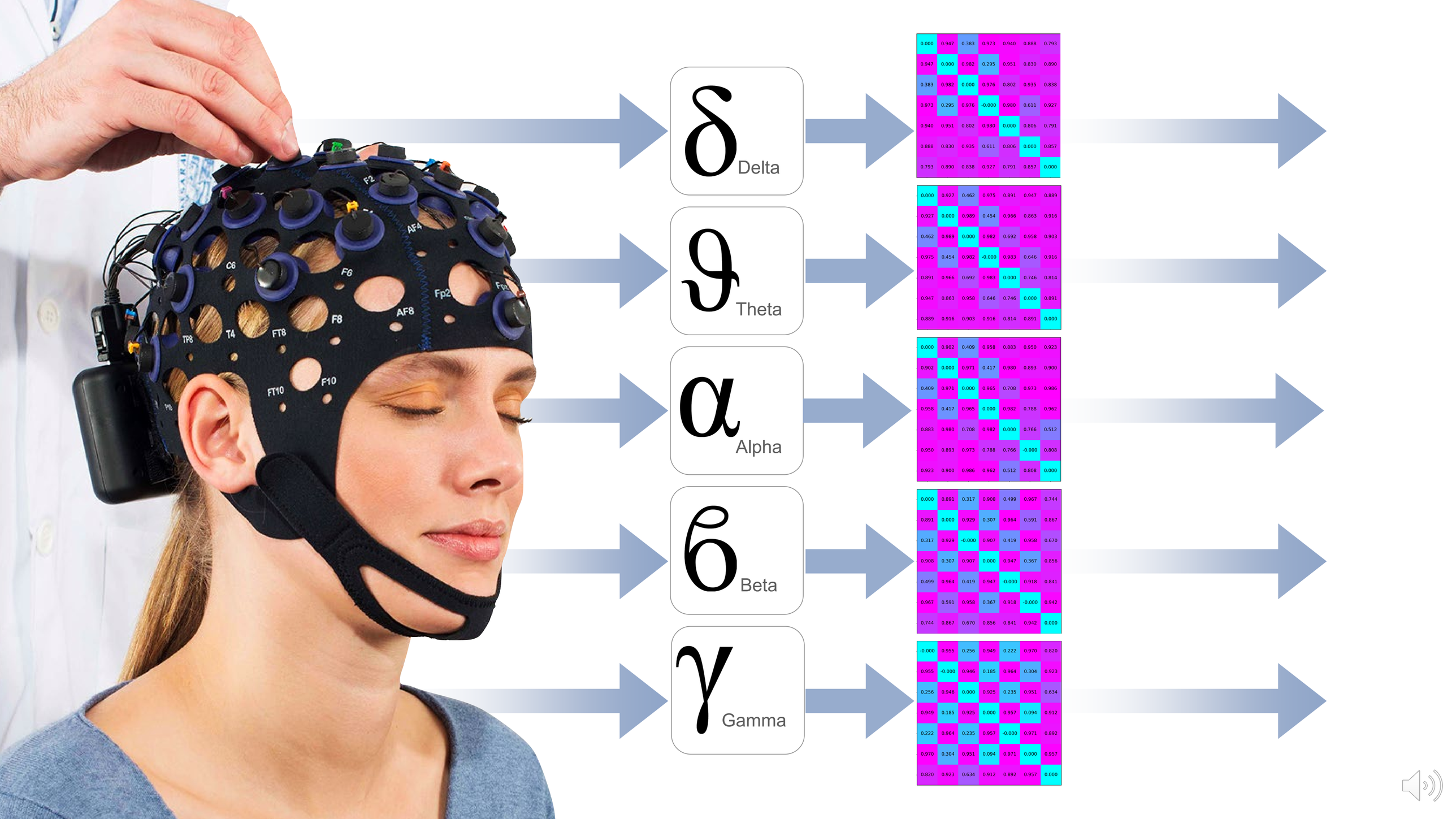


Digital Biomarkers of Complexity
Lmean (average line length in RQA diagram)

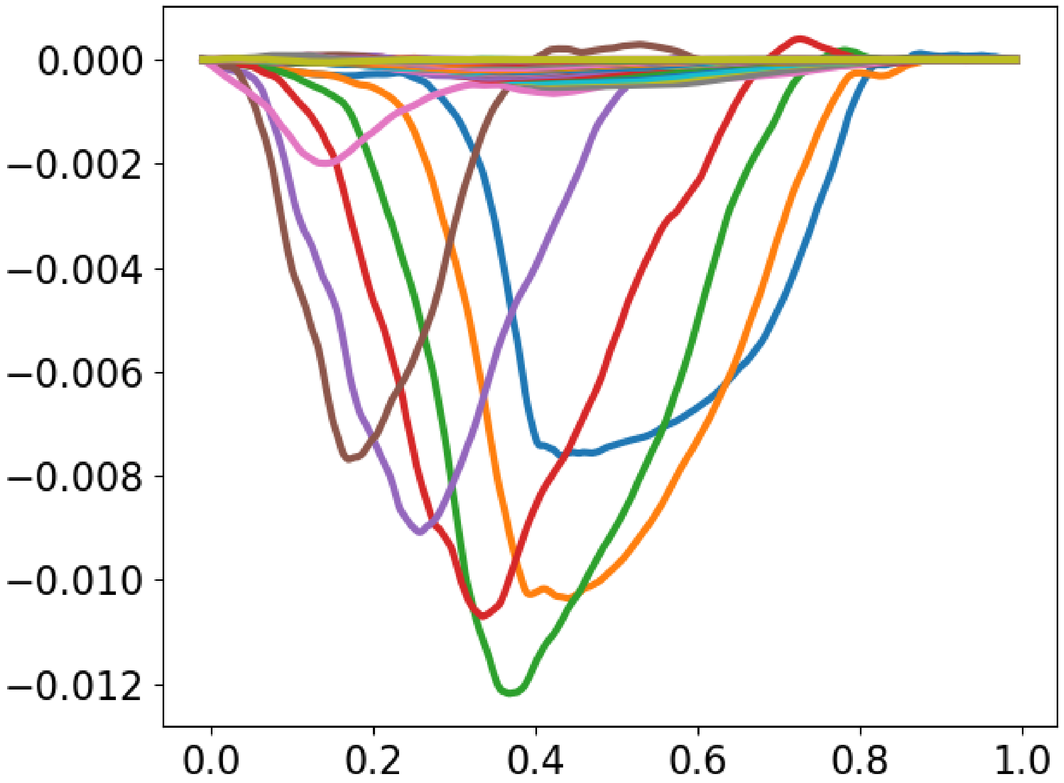


Digital Biomarkers from Topology

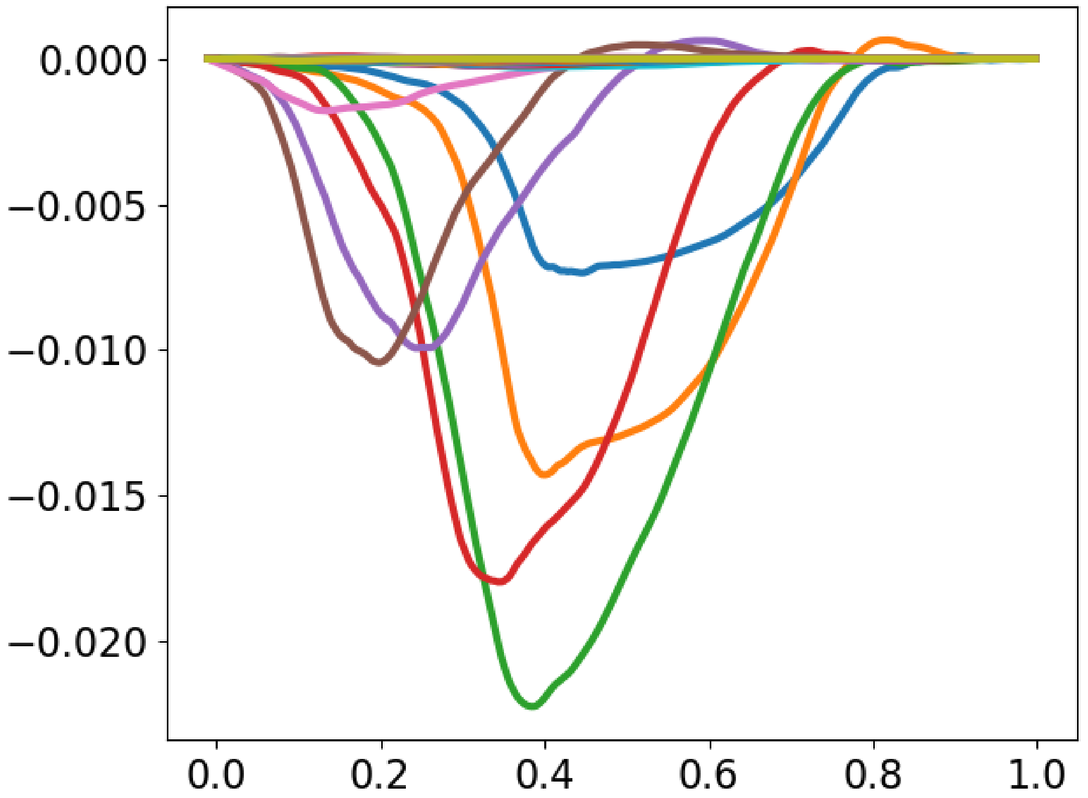



δ Delta
ϑ Theta
α Alpha
ϭ Beta
γ Gamma
F2
AF4
C6
F6
Fp2
AF8
F8
TP8
T4
FT8
FT10
F10

δ Delta



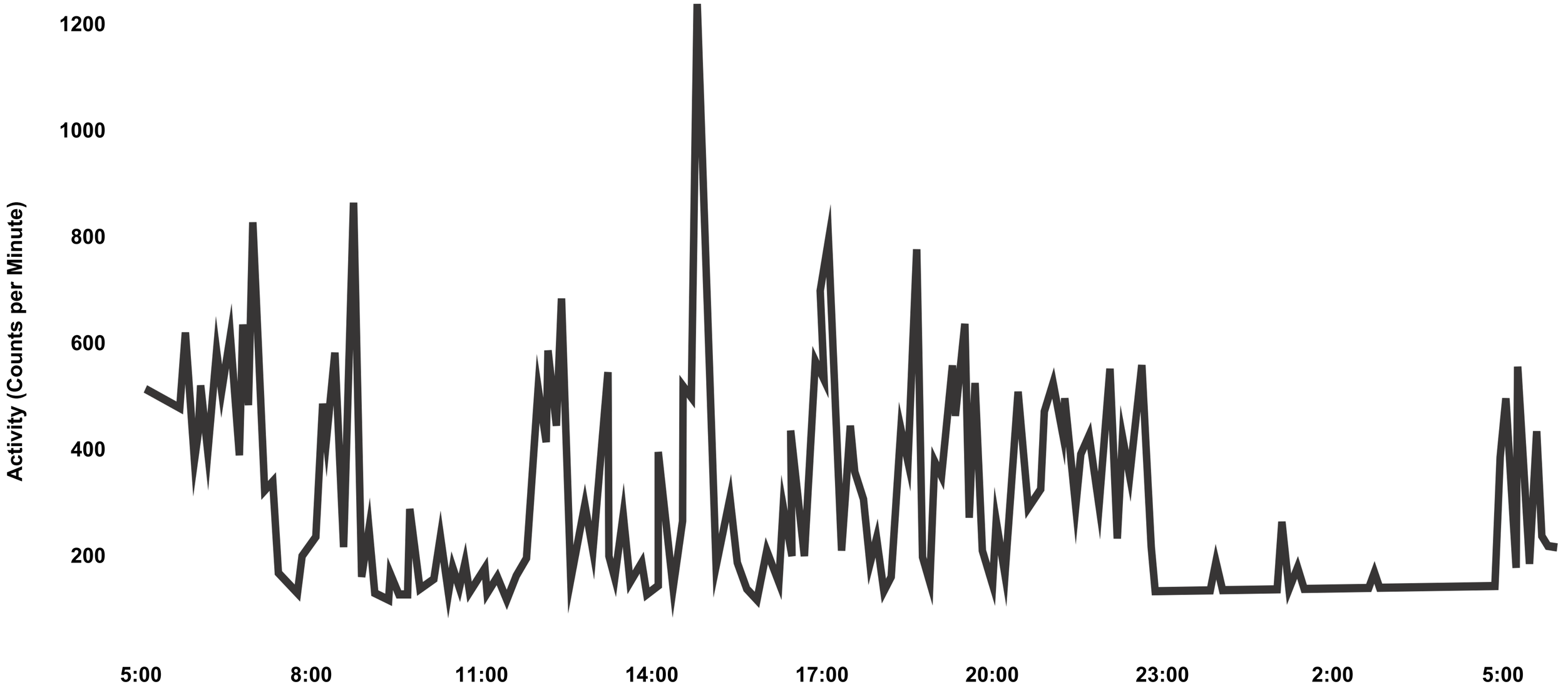
ϑ Theta

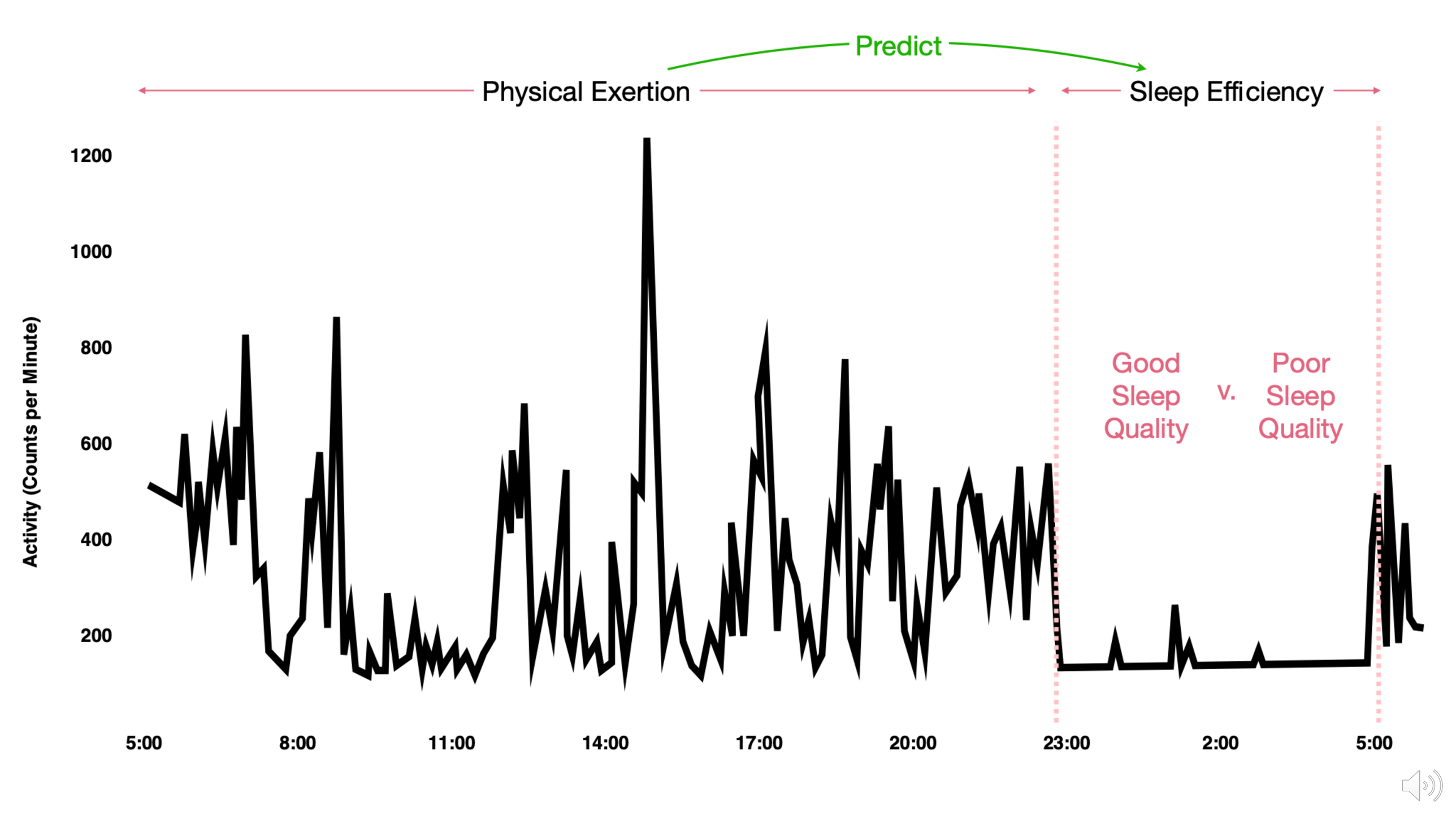


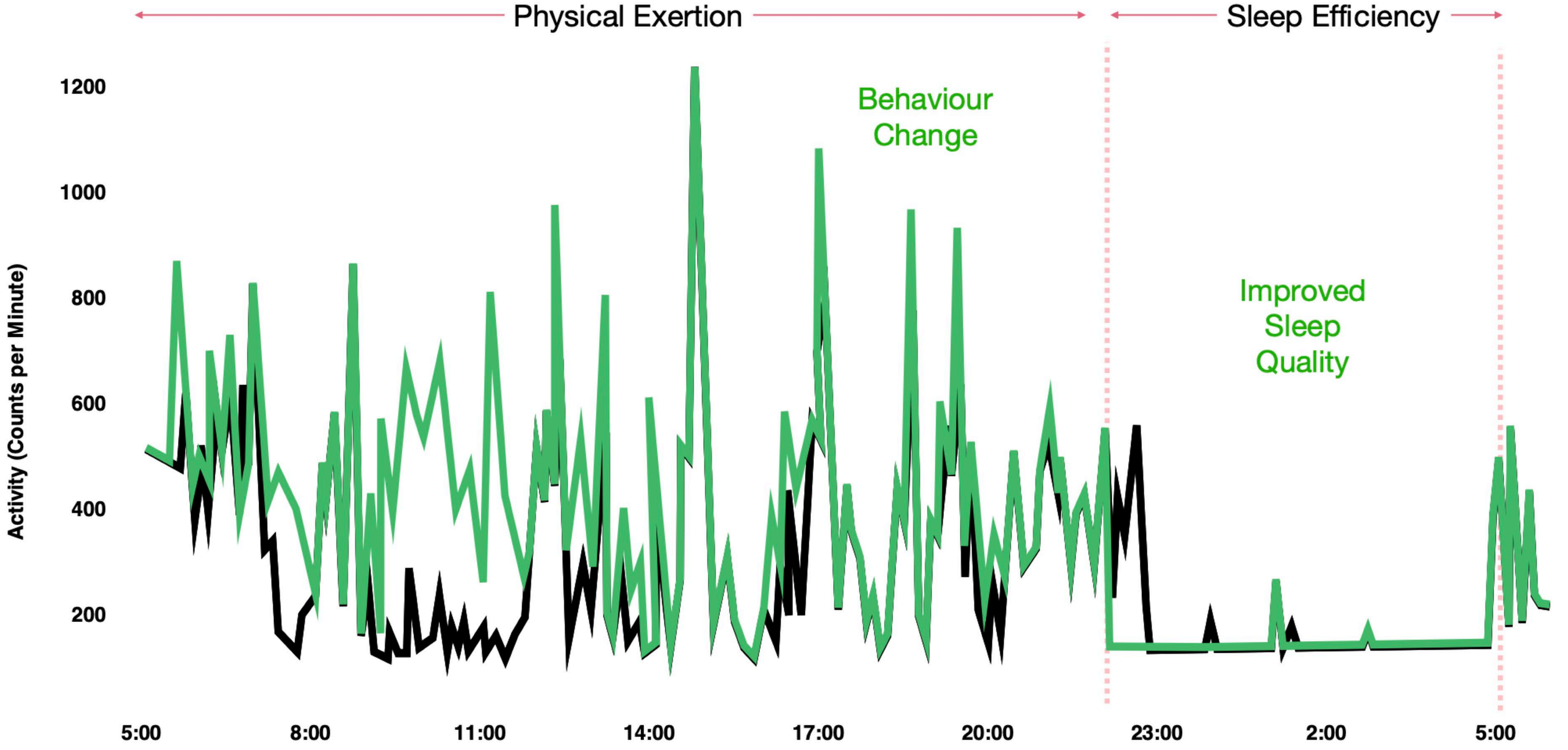
Model

Sleep Apnea?

NOT Sleep Apnea?


Activity (Counts per Minute)
1200
1000
800
600
400
200
5:00
8:00
11:00
14:00
17:00
20:00
23:00
2:00
5:00


Predict
Physical Exertion
Sleep Efficiency
Activity (Counts per Minute)
1200
1000
800
600
400
200
5:00
8:00
11:00
14:00
17:00
20:00
23:00
2:00
5:00
Good Sleep Quality
v.
Poor Sleep Quality

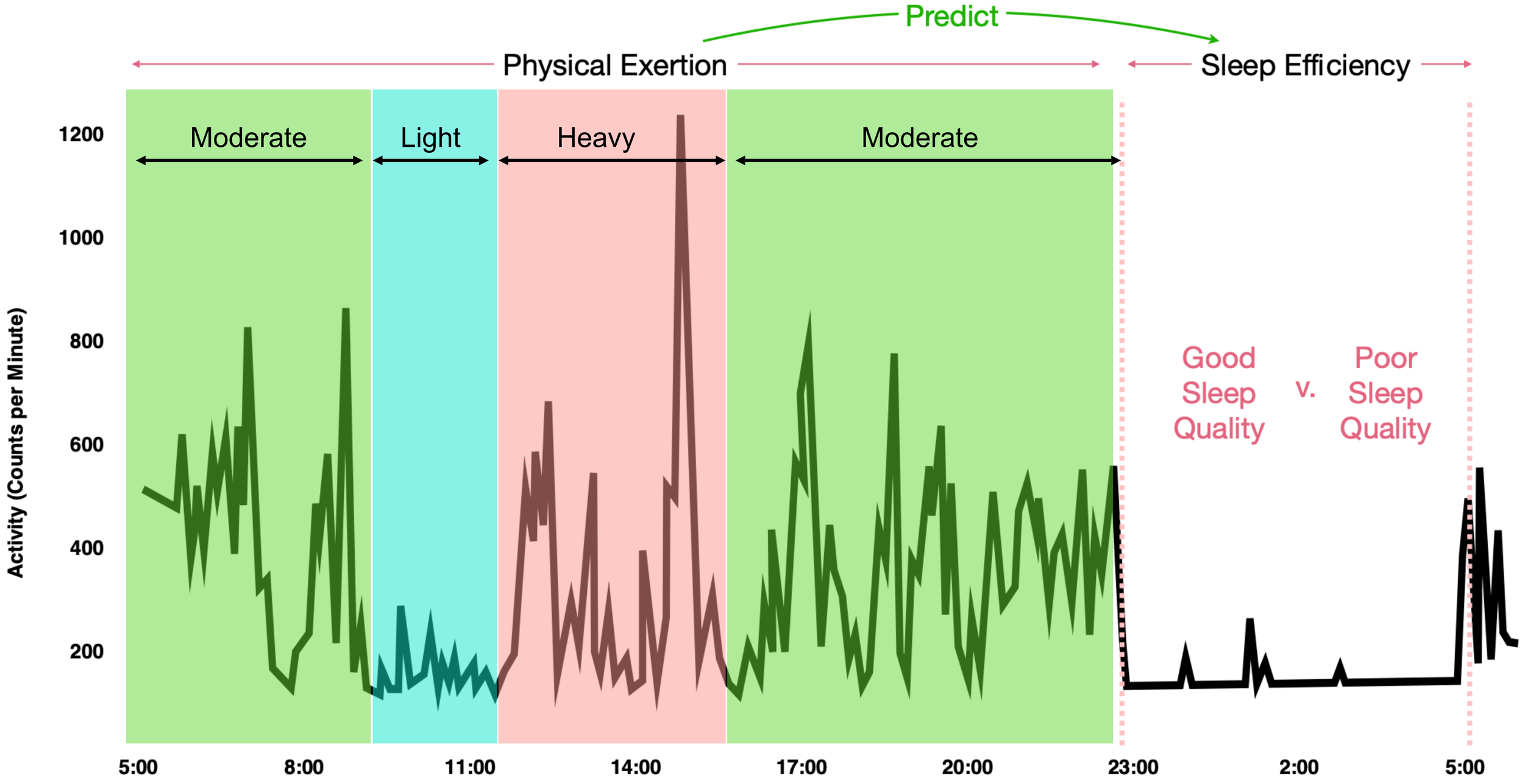

Physical Exertion
Sleep Efficiency
Behaviour Change
Improved Sleep Quality
Activity (Counts per Minute)
1200
1000
800
600
400
200
5:00
8:00
11:00
14:00
17:00
20:00
23:00
2:00
5:00

✘ Predicted Sleep Quality
✓ Recommendation Followed
✓ Resulting Sleep Quality

81%

✘ Predicted Sleep Quality
✘ Recommendation Followed
✘ Resulting Sleep Quality

79%


Predict
Physical Exertion
Sleep Efficiency
Moderate
Light
Heavy
Moderate
Activity (Counts per Minute)
1200
1000
800
600
400
200
Good Sleep Quality
v.
Poor Sleep Quality
5:00
8:00
11:00
14:00
17:00
20:00
23:00
2:00
5:00

Progress

1.

The underlying electrodynamics of the brain can be quantified and utilized as digital biomarkers

2.

Sleep has a strong relationship with epilepsy, and may be key to identifying digital biomarkers of other CNS disorders

3.

Sleep is a mitigable target by smartwatch-driven behavioral modification

Progress

1.

The underlying electrodynamics of the brain can be quantified and utilized as digital biomarkers

2.

Sleep has a strong relationship with epilepsy, and may be key to identifying digital biomarkers of other CNS disorders

3.

Sleep is a mitigable target by smartwatch-driven behavioral modification

Opportunities

1.

Shared dateset generation

- Large representative datasets
- Focused cohorts
- Longitudinal datasets for personalized models
- Multimodal for context-awareness

2.

Investment in computational approaches

- Digital phenotyping tools for early detection and treatment monitoring
- Algorithm development for multimodal signals
- Personalized device-agnostic models
- Collaborative approaches with neurophysiologists

THE SATH LAB

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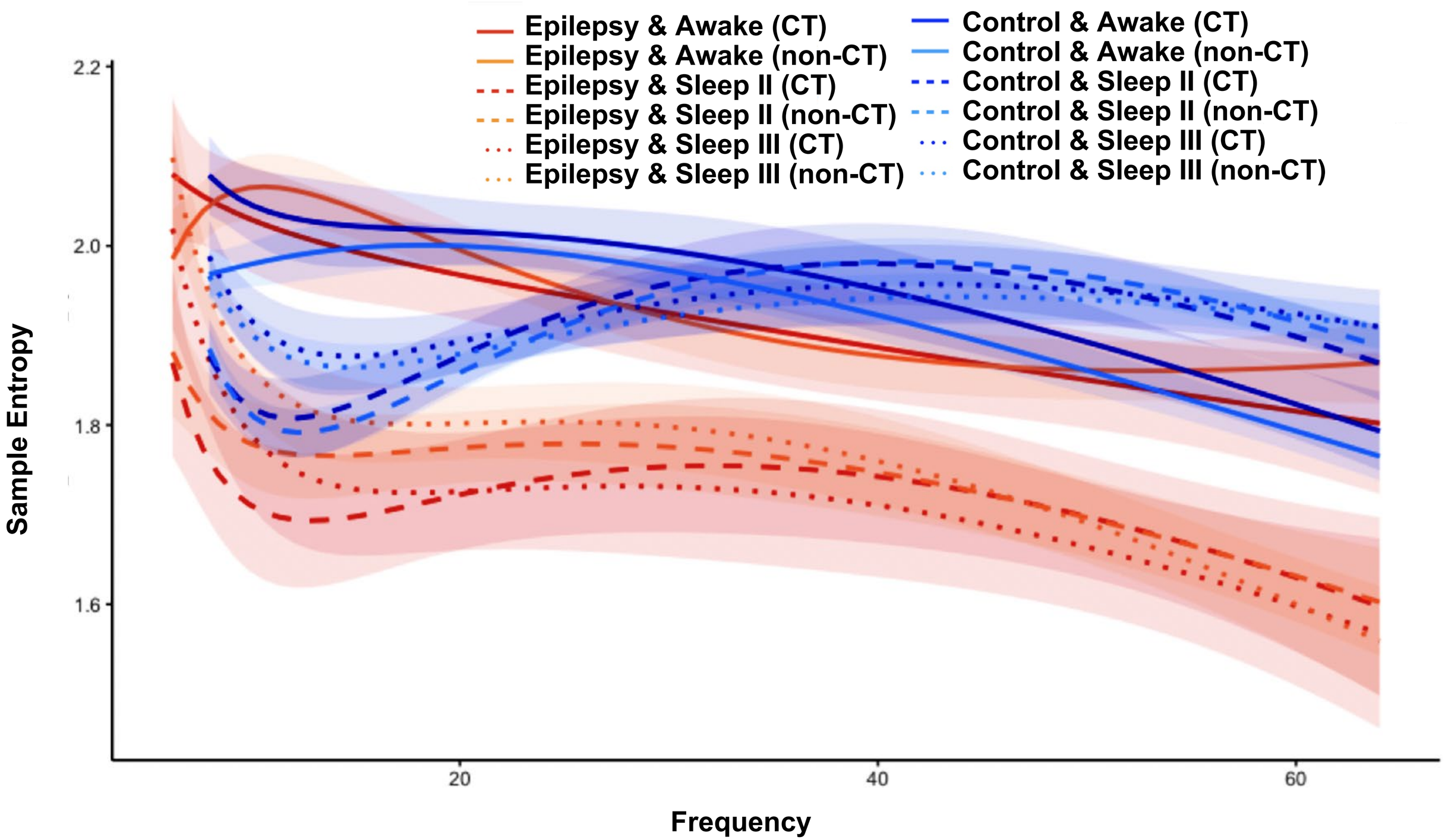
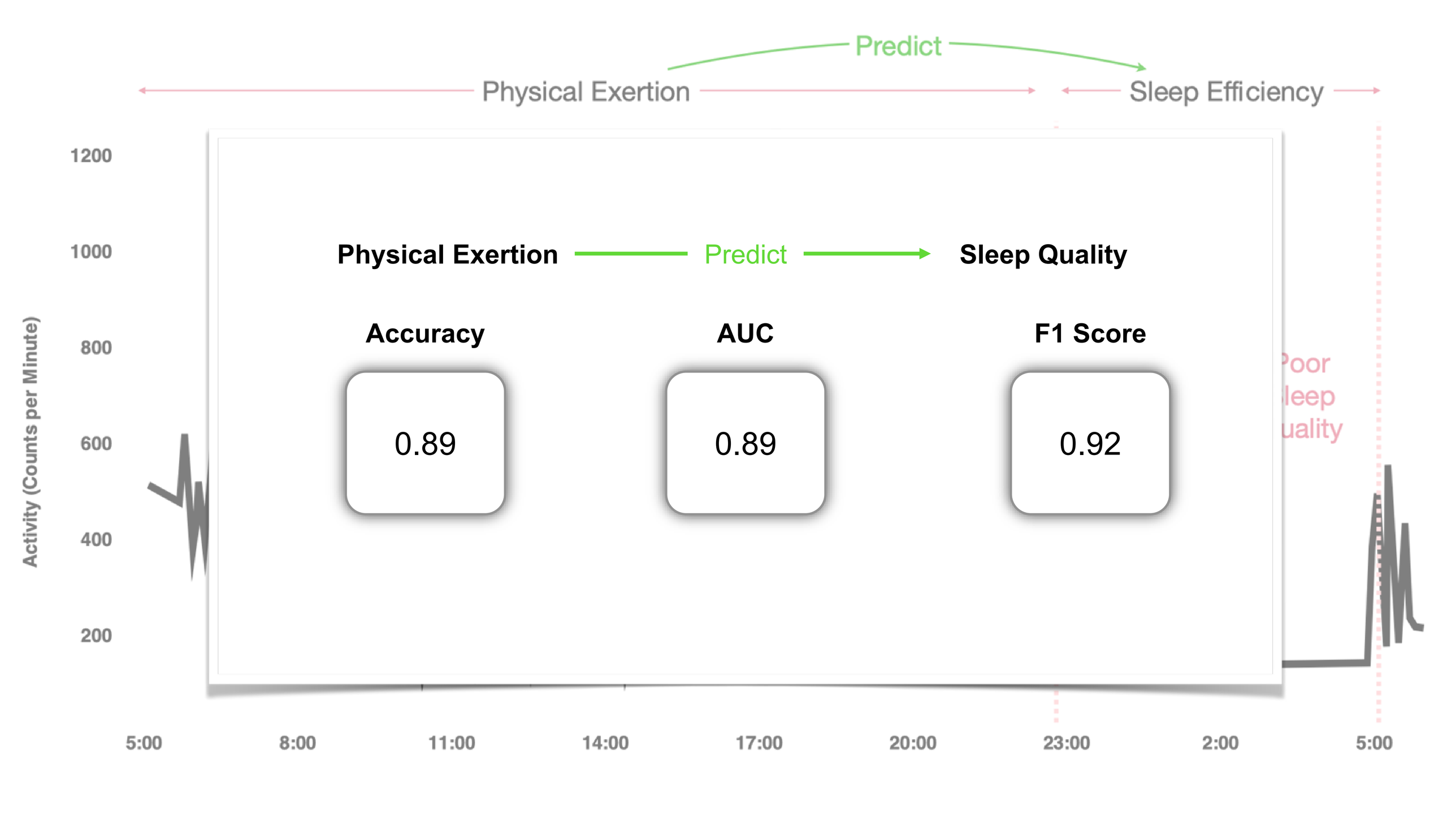
AWARDS & FUNDING

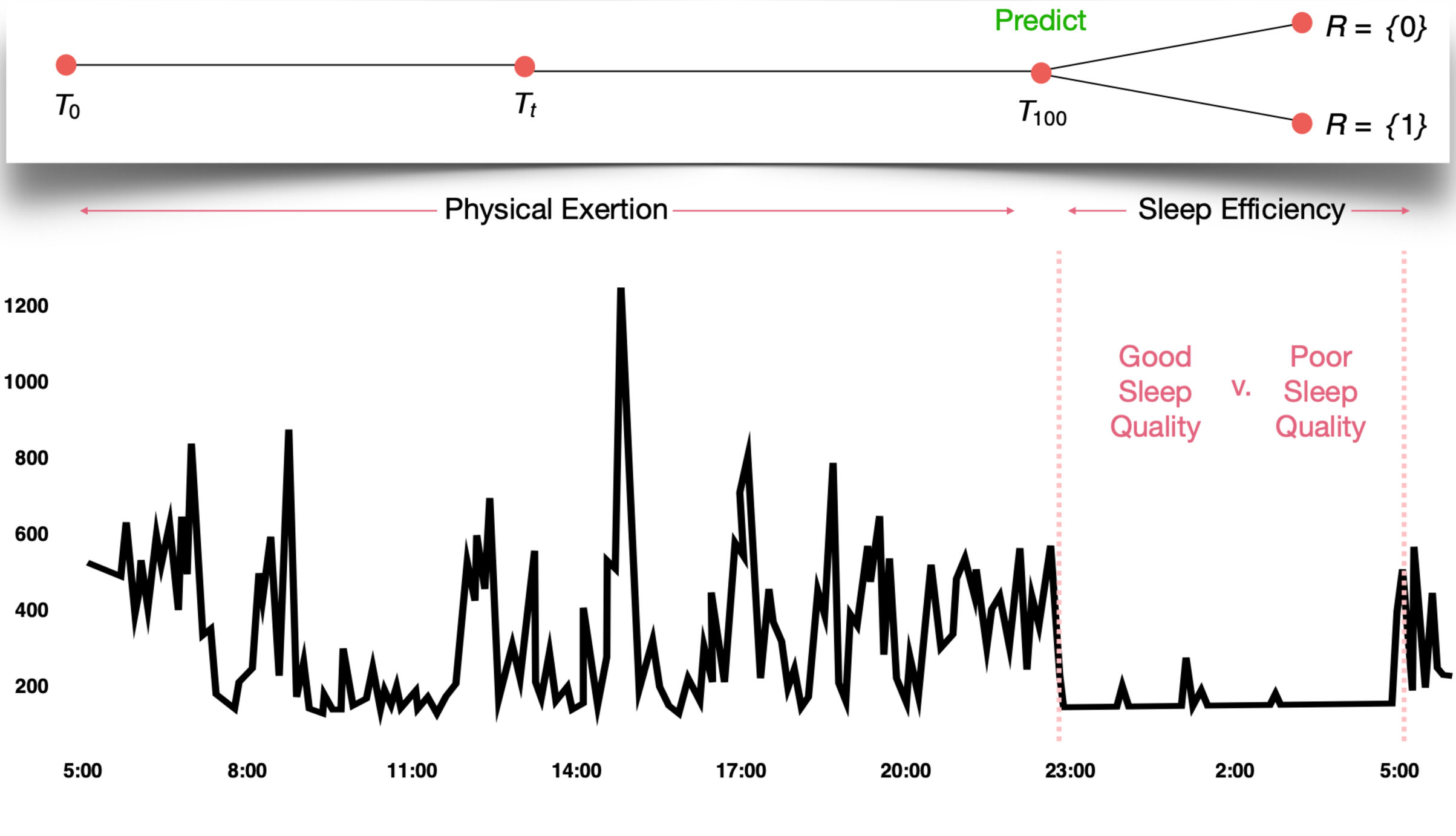
Doctoral Dissertation Award

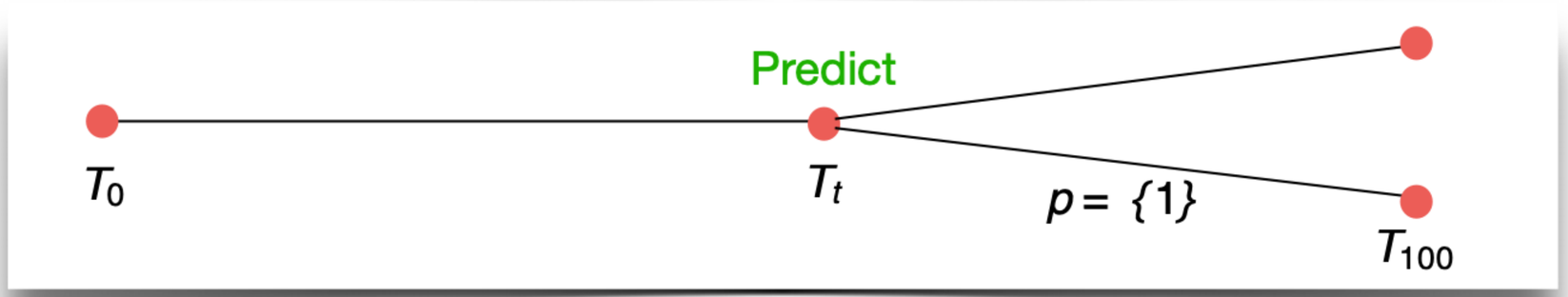
Nita Akoh
Jennie An
Ohida Binte Amin
Laura Domenech-Estrellas
Harshit Pandey
Shashank Manjunath
Devashish Sood

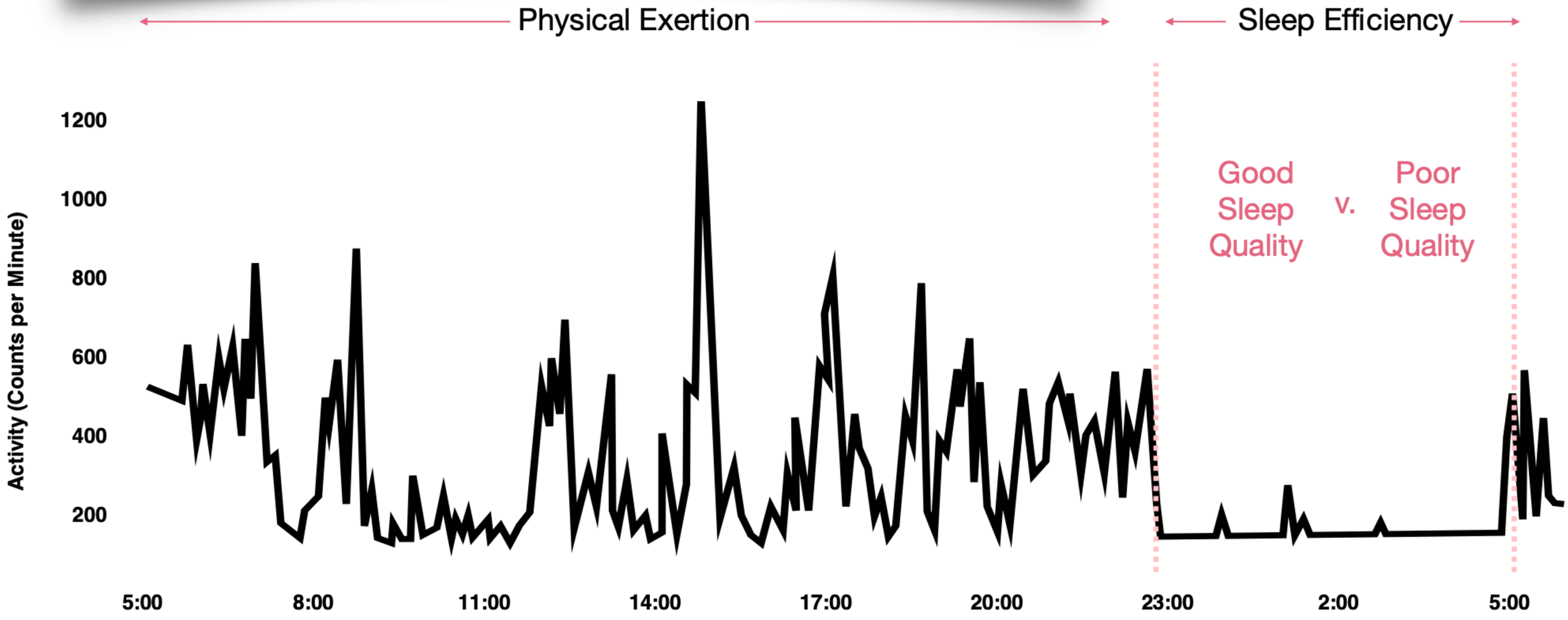
COLLABORATORS


Epilepsy & Awake (CT)
Epilepsy & Awake (non-CT)
Epilepsy & Sleep II (CT)
Epilepsy & Sleep II (non-CT)
Epilepsy & Sleep III (CT)
Epilepsy & Sleep III (non-CT)
Control & Awake (CT)
Control & Awake (non-CT)
Control & Sleep II (CT)
Control & Sleep II (non-CT)
Control & Sleep III (CT)
Control & Sleep III (non-CT)
Sample Entropy
2.2
2.0
1.8
1.6
20
40
60
Frequency


Predict
Physical Exertion
Sleep Efficiency
Physical Exertion
Predict
Sleep Quality
Accuracy
AUC
F1 Score
0.89
0.89
0.92
Activity (Counts per Minute)
1200
1000
800
600
400
200
5:00
8:00
11:00
14:00
17:00
20:00
23:00
2:00
5:00


Predict
$R = \{0\}$
$R = \{1\}$
T_0
T_t
T_{100}
Physical Exertion
Sleep Efficiency
Activity (Counts per Minute)
1200
1000
800
600
400
200
Good Sleep Quality
v.
Poor Sleep Quality
5:00
8:00
11:00
14:00
17:00
20:00
23:00
2:00
5:00


Predict
T_0
T_t
$p = \{1\}$
T_{100}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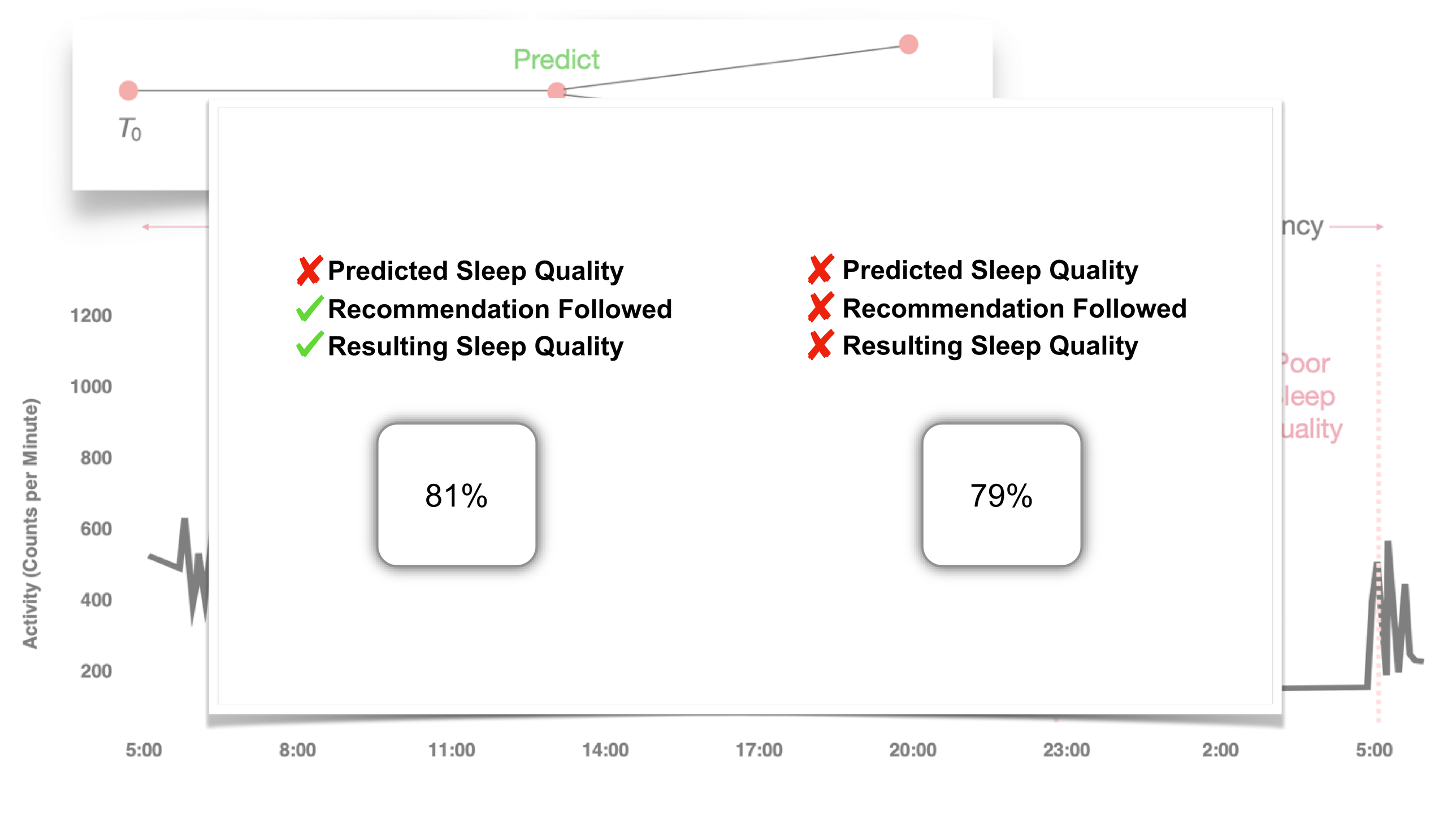
Predict
T_0
ncy
Poor
leep
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