Investigating the Link Between Lifetime Physical Activities and EEG Aperiodic Slope in Adults Aged 55+

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Project “Modifiable bio and life-style markers in predicting cognitive decline (MOBILE-COG)”

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INTRODUCTION

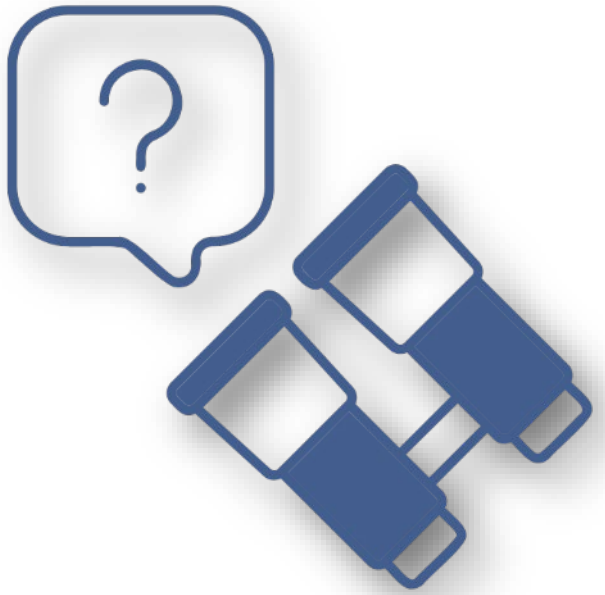
Relevance

- **Overall cognitive** functioning **declines with age**
- **Physical activity improves** cognitive function in older adults
- Most studies **focus on sport- or exercise-related** physical activity

(Bherer et al., 2013; Dhahbi et al., 2025; Glisky, 2007; Klimova & Dostalova, 2020; Northey et al., 2018; Patel et al., 2022)

Gaps in research

- How are **broader, everyday physical activities** related to cognitive functioning?
- What are the **effects of lifelong, diverse** physical activities?
- How do they **relate to cognitive functioning in aging**?



From cognitive function to neural dynamics

My master`s thesis research showed an association between **working memory performance** and **lifetime work-related physical activities**

This raised a question:

Could similar relationships emerge when examining **resting-state neural dynamics** in relation to **lifetime physical activity** patterns measured with the same approach?

Aim

To investigate how **different types of lifetime physical activities** and their **accumulated motor reserve** are associated with the **EEG aperiodic slope** - a neural marker linked to **overall cognitive functioning in aging**

Aging

Time-related decline in functional integrity across biological and behavioral levels, gradually reducing one`s ability to adapt and function in a constantly changing environment

(Gilbert, 2000; Kyriazis, 2020)

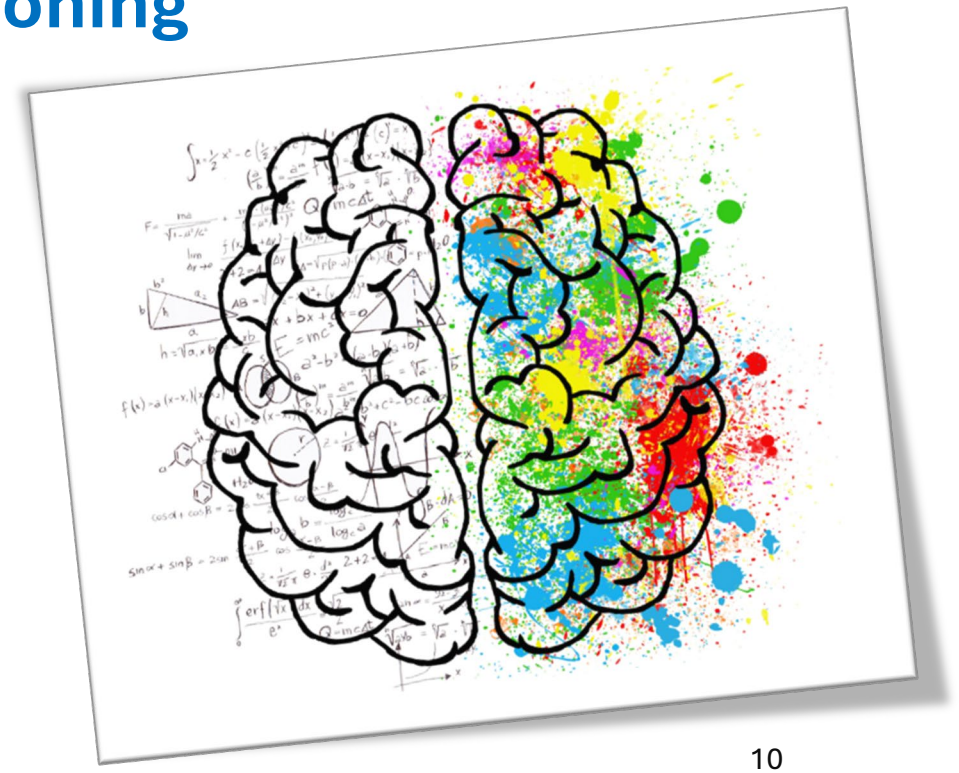
Cognitive functioning

«**The ability** to **perceive** and **react**, **process** and **understand**, make **decisions** and produce **appropriate responses** to the environment»

(Tavares et al., 2023)

Cognitive functions

1) **Basic mental abilities for performing any activity**
2) **Mental processes involved in the acquisition of knowledge, manipulation of information, and reasoning**
    - attention,
    - memory,
    - learning,
    - perceptual motor function,
    - executive functions,
    - decision making,
    - language



(Bufano et al., 2024; Kiely, 2014)

Cognitive abilities

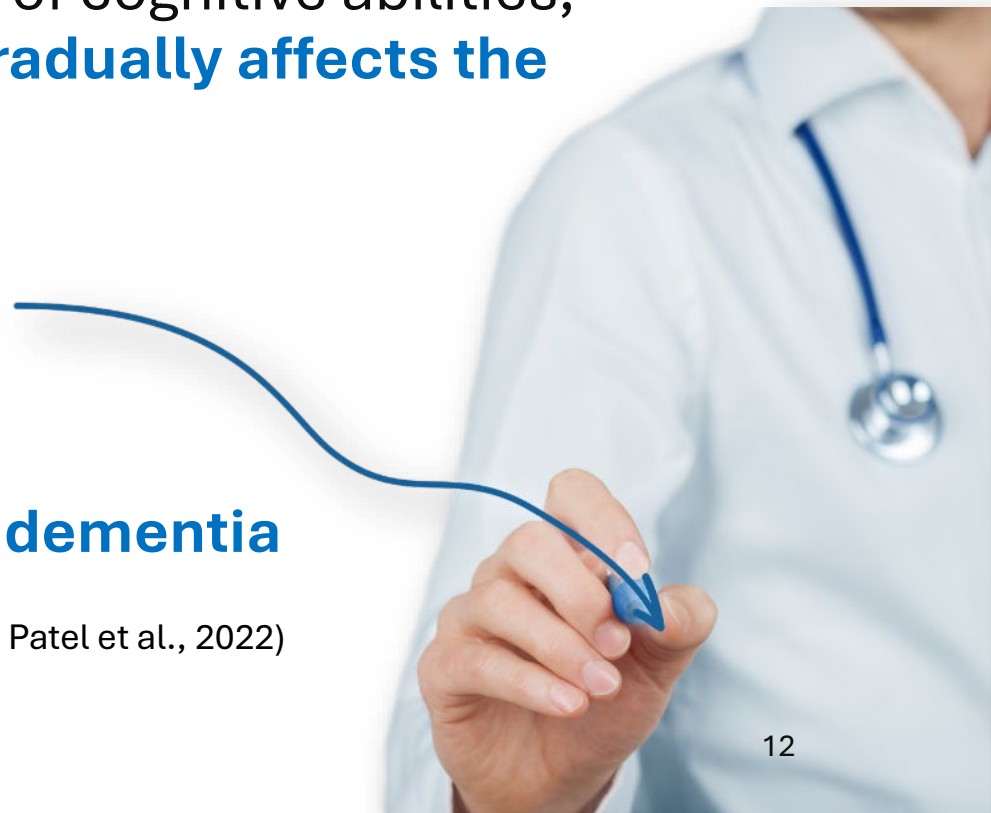
1. **Fluid abilities**
   - cognitive abilities that primarily rely **on processing aspects of cognition**
     - ***psychomotor speed, memory, problem solving, and abstract reasoning***

2. **Crystallized abilities**
   - primarily reflect **declarative and procedural knowledge** explicitly **acquired from one's sociocultural environment**
     - ***vocabulary, literacy, numeracy, knowledge of world history and current events***

(Lövdén et al., 2020; Stawski et al., 2010)

Ageing & cognitive functioning (1)

- Cognitive functioning **declines with aging**
- However, this **decline does not occur uniformly**
- Some older adults maintain relatively high levels of cognitive abilities, yet **even in optimal cases, the aging process gradually affects the efficiency of these functions**



After the age of 70 y

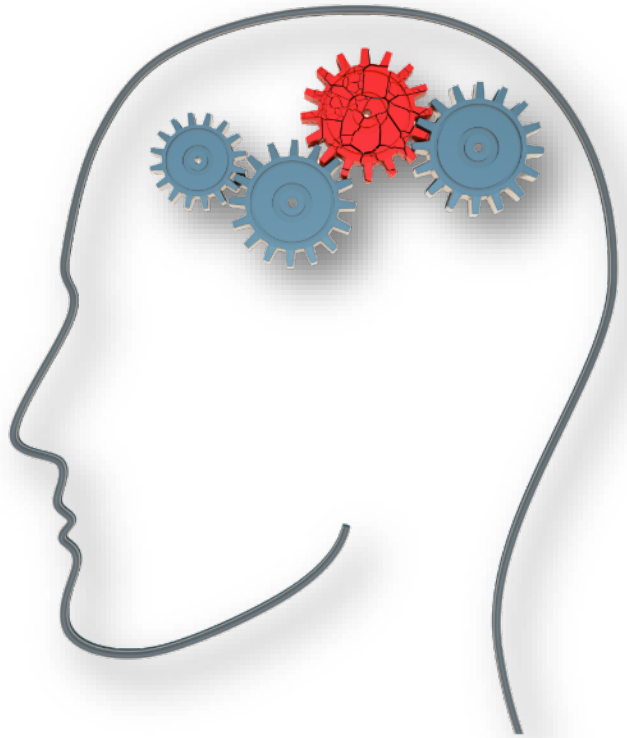
- **~16% mild cognitive impairment** (MCI) + **~14% dementia**

(Cabeza et al., 2018; Glisky, 2007; Morley et al., 2015; Patel et al., 2022)

Ageing & cognitive functioning (2)

Fluid cognitive (*processing aspects of cognition*) **abilities decline steeply during healthy human aging**

(Mitchell et al., 2023)



Physical activities

Any **bodily movement** produced by skeletal **muscles** that results in **energy expenditure** **(above the resting state level)**

(Caspersen et al., 1985; Malm et al., 2019)

Physical activities, ageing & cognitive functioning

In elderly people

- Regular **aerobic exercise**
  - **mitigates** age-related cognitive decline
  - **enhances executive function, memory, and mood regulation**

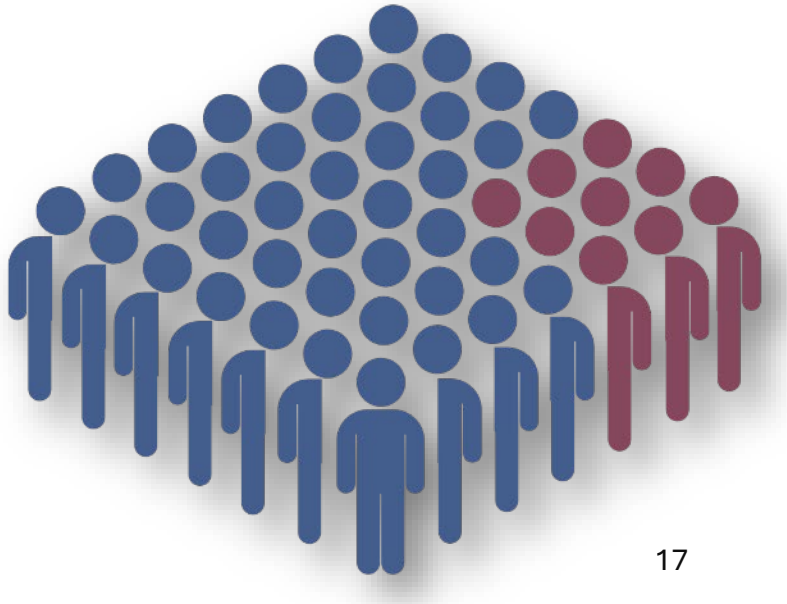
- **Higher level of their physical activity**
  - associated with **higher visual space, attention, language, abstract ability**
  - a **protective factor for MCI**

(Dhahbi et al., 2025; Wang et al., 2023)

METHODS

Sample

- **N = 54**
  - **M_{age} = 68,15**; SD = 6,87
  - Age range: 56-84 years
  - 35% male (n = 19), **65% female** (n = 35)



Research tools – physical activities

Lifetime physical activities

- **Motor reserve index questionnaire (MRIq)**
  - developed by Pucci and Mondini (2020) and adapted in Latvian by Freibergs and Šneidere (2024)

Spectrum of physical activities

No.	Physical Activity Group	Examples
1	Bicycling	Mountain, leisure, stationary cycling
2	Walking	Hiking, climbing stairs, leisure walking
3	Conditioning Exercise	Weightlifting, yoga, therapeutic exercise
4	Music Playing	Playing accordion, drums, guitar, trumpet
5	Water Activities	Swimming, surfing, playing water volleyball
6	Dancing	Ballet, folk dancing, salsa, tango
7	Occupation	Working in a bakery, lifting heavy objects, firefighter work
8	Winter Activities	Skiing, mountain climbing, snow shoveling
9	Hunting & Fishing	Fishing, duck hunting, sitting/standing in a boat
10	Running	Jogging, marathon, triathlon
11	Religious Activities	Ceremonies, praying, pilgrimage
12	Home	Mopping floors, dusting, cooking
13	Self-Care	Bathing, dressing, hairstyling, shaving
14	Volunteering	Walking, sitting, supervising children or animals
15	Home Renovations	Carpentry, wallpapering, painting
16	Sexual Activities	Active, passive (kissing), moderately active
17	Video Games	VR (standing/sitting), active or passive gaming
18	Sports	Hockey, boxing, football, basketball, billiards
19	Gardening	Digging soil, mowing lawn, watering
20	Transportation	Driving a car, motorcycle, airplane, rickshaw
21	Inactivity	Watching TV, meditating, lying down, using the phone
22	Miscellaneous	Playing cards, laughing, crafts, using a computer

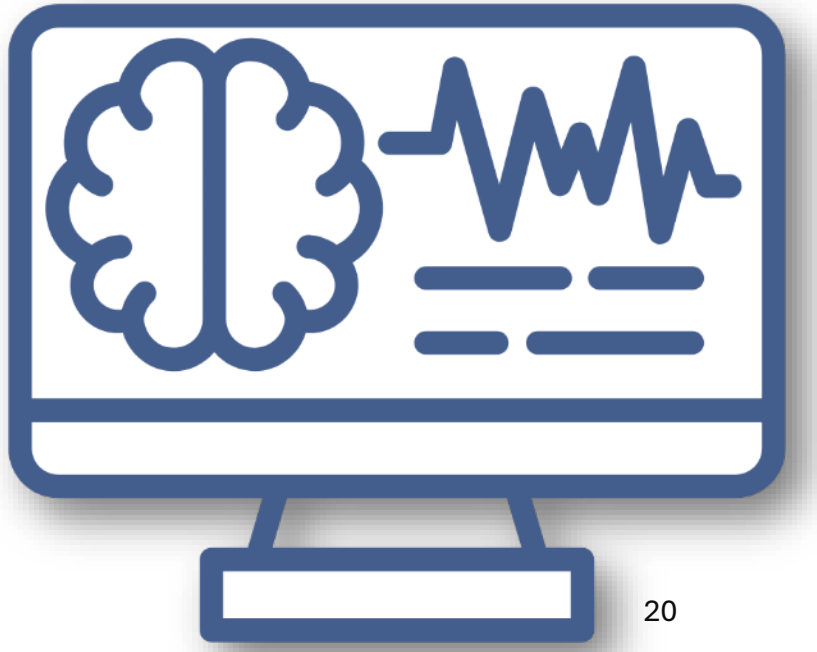
- **>1100** types of physical activities
- **22** groups

(Herrmann et al., 2024)

Research tools – cognitive functioning

- **Rs-EEG recording**
  - **6 min:** 3 min eyes open + 3 min eyes closed
  - g.tec **32-channel** g.Nautilus RESEARCH headset
  - **active** gel **electrodes** placed according to the 10-20 system

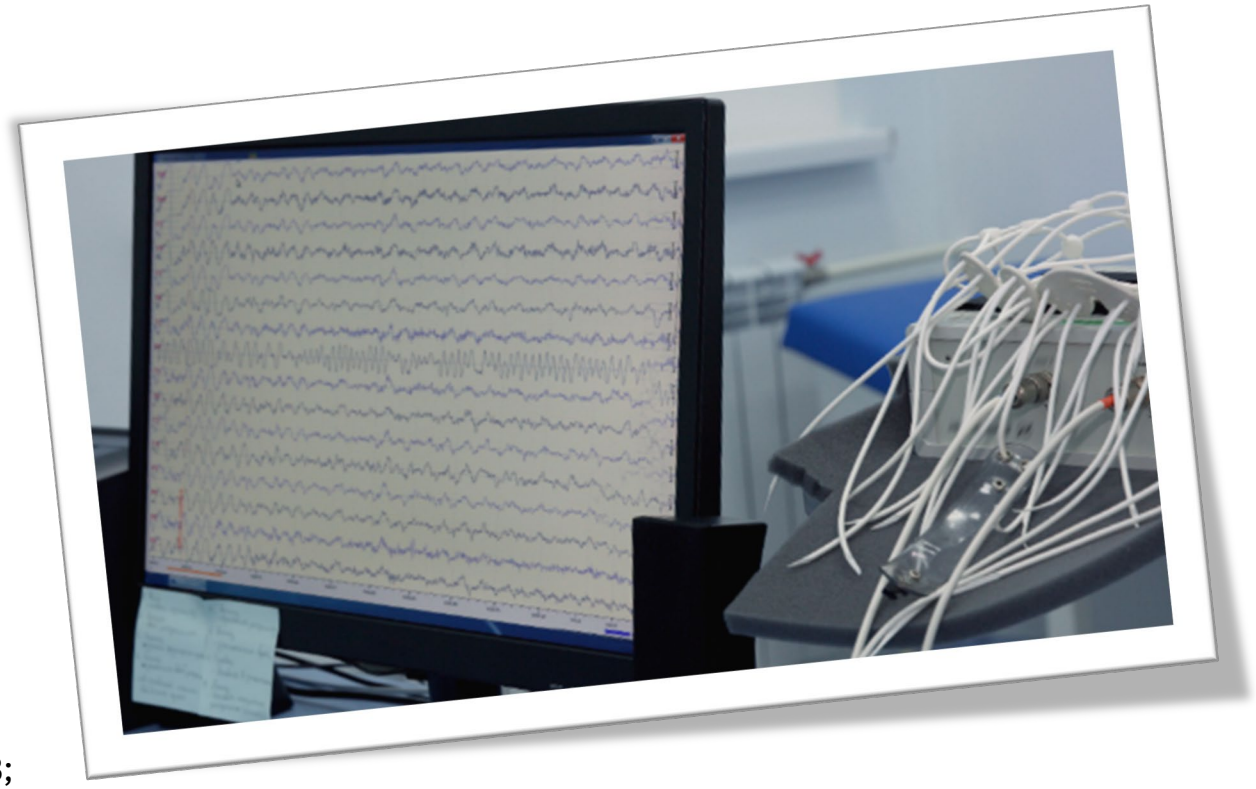
- **Rs-EEG preprocessing**
  - **EEGLAB** v2024.1 in **MATLAB** R2024a
  - Data downsampled to **256 Hz**
  - Bandpass filter **1 Hz – 45 Hz**
  - aperiodic slope steepness calculated with **FOOOF algorithm in Python**



Electroencephalography (EEG)

A non-invasive method for measuring the brain`s electrophysiological activity

- **Resting-state EEG**
  - without stimuli
  - in resting conditions
- **Task-based EEG**
  - under the influence of various stimuli
  - during tasks

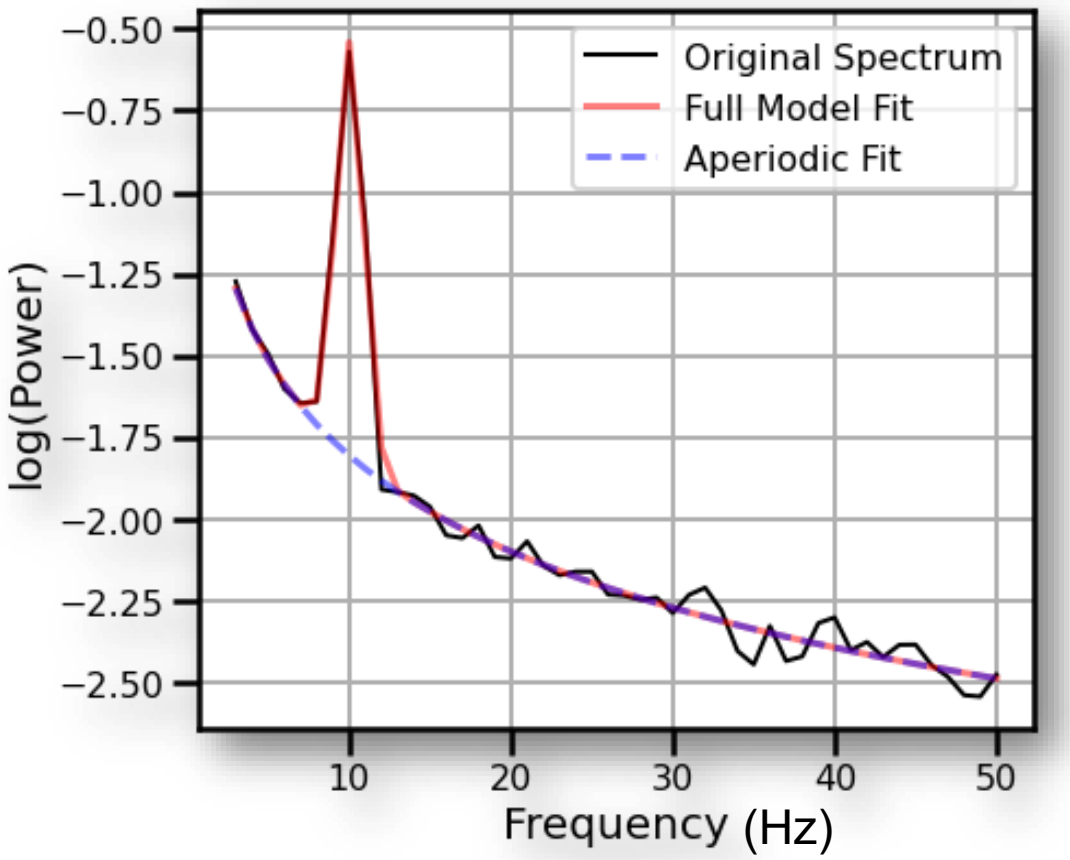


(Gu et al., 2022; Kaushik et al., 2023; Li et al., 2020; Rayi & Murr, 2025)

Aperiodic slope

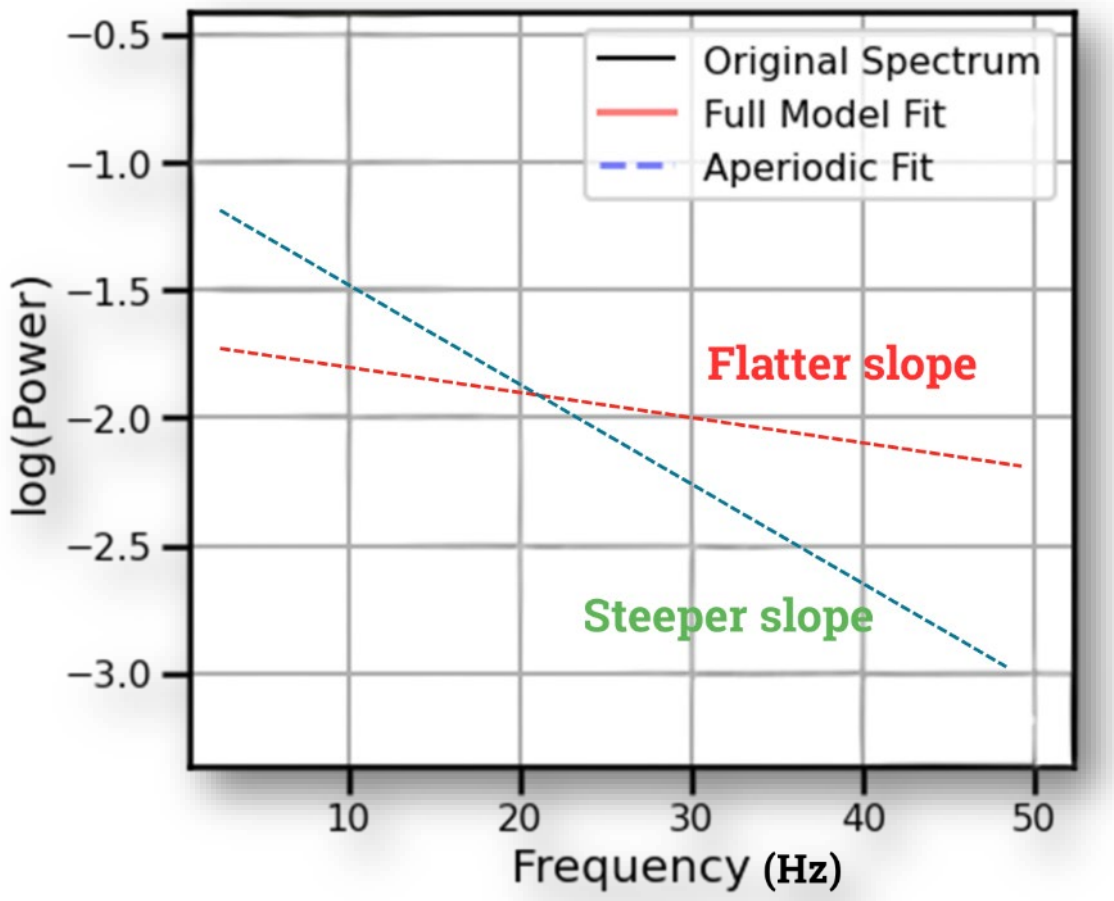
- **Resting-state EEG variable**:
  - follows a **1/f^χ** distribution, where
    - f is frequency and
    - χ is the exponent that determines how quickly electrical power decreases as frequency increases
- **If χ < 1, the curve is flatter**

(Donoghue et al., 2020)



Aperiodic slope & cognitive functioning

- A flatter curve is associated with **poorer cognitive performance**, various **mental disorders**, and **aging**
- In the context of aging, a flatter curve generally indicates **weaker neural inhibition**



(Finley et al., 2024; Montemurro et al., 2024; Pei et al., 2023)

RESULTS

Initial results

N=33

- a correlation was found only **between the median aperiodic slope and lifetime household physical activities** (rs=.432, p=.012)

Spearman`s Correlations Between Median Aperiodic Slope and MRIq Variables (1)

N=54

MRIq variable	Spearman`s rho	*p* -value
MRIq Household activities	-0.178	0.199
MRIq Walking	-0.024	0.863
MRIq Leisure-time activities	-0.057	0.68
MRIq Sports activities	-0.011	0.937
MRIq Caregiving	0.079	0.569
MRIq Work activities	0.186	0.178
MRIq Total score	0.019	0.89

Spearman`s Correlations Between Median Aperiodic Slope and MRIq Variables (2)

N=54, controlling for **Age**

MRIq variable	Spearman`s rho	*p* -value
MRIq Household activities	-0.212	0.127
MRIq Walking	-0.065	0.644
MRIq Leisure-time activities	-0.092	0.514
MRIq Sports activities	-0.058	0.681
MRIq Caregiving	-0.062	0.662
MRIq Work activities	0.149	0.288
MRIq Total score	-0.078	0.579

Note. Controlling for 'Age, years'

Spearman`s Correlations Between Median Aperiodic Slope and MRIq Variables (3)

N=54, controlling for **Gender**

MRIq variable	Spearman`s rho	*p* -value
MRIq Household activities	-0.182	0.192
MRIq Walking	-0.052	0.714
MRIq Leisure-time activities	-0.05	0.722
MRIq Sports activities	-0.027	0.848
MRIq Caregiving	0.063	0.652
MRIq Work activities	0.178	0.201
MRIq Total score	0.012	0.934

Note. Controlling for 'Gender'

CONCLUSIONS

Conclusions

1. **No significant correlations** were found **between median aperiodic slope and** MRIq-measured **physical activities** ($p > .05$)

2. This suggests that resting-state neural excitation/inhibition balance (reflected by aperiodic slope) **does not strongly relate to habitual physical activity levels**

Potential explanations

1. Quality **(recency, intensity, cognitive demand)** may matter more than quantity of physical activity
2. Cross-sectional self-reports may miss subtle or cumulative brain effects of physical activity; **longitudinal or experimental designs** could capture them
3. Physical activity related brain changes may occur **in subcortical or white matter regions**, not well captured by surface EEG
4. Physical activity effects may be **task-specific**
5. **Homogenity by age** effects in our study sample
6. **Age-related slope flattening** may mask physical activity effects

What we are doing now

1. Developing a **new Motor Reserve calculator**
2. Gathering data via **smartwatches**
3. Conducting **task-based EEG (ERP)** data collection
4. Acquiring **MRI DTI scans**
5. Performing extensive **psychological assessments**

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<u>P.S.</u> Not all wider spectrum physical activity improves cognition in older adults! ☺

Thank you!