

Event-related Synchronisation Responses to N-back Memory Tasks Discriminate Between Healthy Ageing, Mild Cognitive Impairment, and Mild Alzheimer's Disease



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Motivation

- ✓ Need for an accurate and cost-effective biomarker to diagnose MCI, since it has been pointed as an important risk factor in the development of AD
- ✓ EEG can reveal functional impairment long before actual tissue loss occurs, thus opening doors for very early diagnostics
- ✓ ERS/ERS can extend the well-established resting-state frequency-specific analysis to task-related EEG and also overcome the full-band limitation of ERP

Participants and N-back task

❑ Participants

- ❑ 27 healthy elderly (HE), 21 subjects diagnosed with mild cognitive impairment (MCI) and 16 mild Alzheimer's disease (AD) patients

❑ N-back task (button press after visual stimuli)

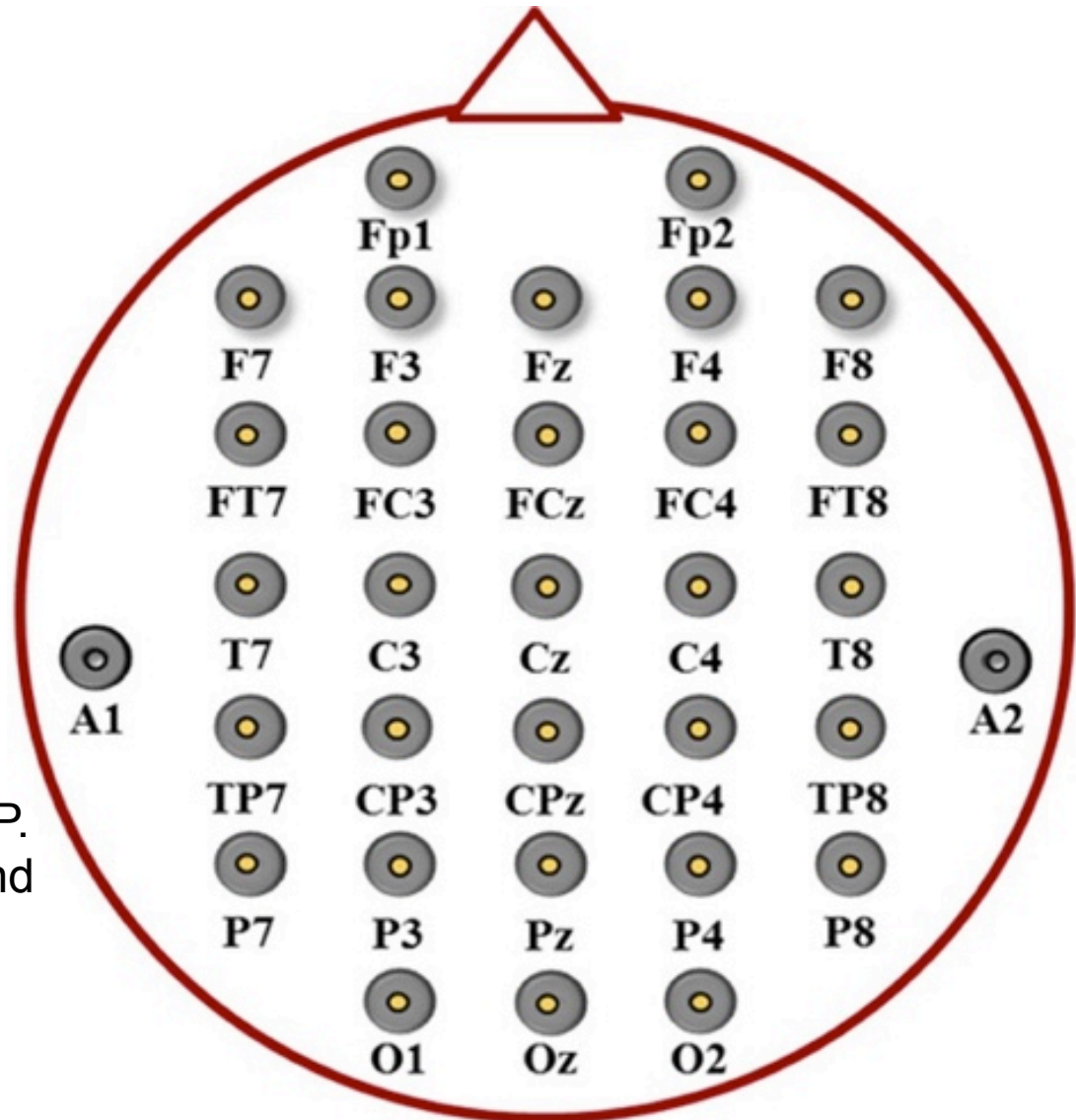
- ❑ N-back are (visual) working memory (WM) tasks with increasing levels of memory load (2-second ISI)
 - ❑ 0-back: a digit who they are asked to remember
 - ❑ 1 or 2-back: a digit presented 1 or 2 trials before
- ❑ Response: “match” (40%) or “non-match” (60%) trials

EEG Signal Processing

□ EEG pre-processing

- 32-channel (10-20 system) Neuroscan device, 500 Hz sampling rate, left earlobe reference
- lowpass filtering (57 Hz), downsampling to 125 Hz, highpass filtering (1.2 Hz), artifacts removal (ICA)
- bandpass filtering : theta (4 – 8 Hz), alpha (8 – 12 Hz), beta (12 – 30 Hz) and gamma (30 – 45 Hz)
- 2-second epochs ranging from -500 ms to 1500 ms
- Squared samples smoothed with a 13-tap moving average filter: bandpass energy signals $E(t)$

EEG Signal Processing



Lin, Y. P., Yang, Y. H., and Jung, T. P. (2014). Fusion of EEG dynamics and musical contents for estimating emotional responses in music listening. *Front. Neurosci.* 8:94. doi: 10.3389/fnins.2014.00094

EEG Signal Processing

□ ERD/ERS quantification

delay correction, the pre-stimulus reference (average energy from -500 to 0 ms) of the smoothed bandpass energy signals (termed R) were computed. Lastly, the percentage power decrease (%ERD) or increase (%ERS) were computed as

$$\%ERD(t) = 100 \times \frac{E(t) - R}{P}, \quad (1)$$

where P indicates average energy of the entire epoch (i.e., from -500 to 1500 ms). So, when $\%ERD(t)$ is negative it means power decrease, otherwise it means the power has increased as compared to the baseline. The main difference be-

Statistical Analysis

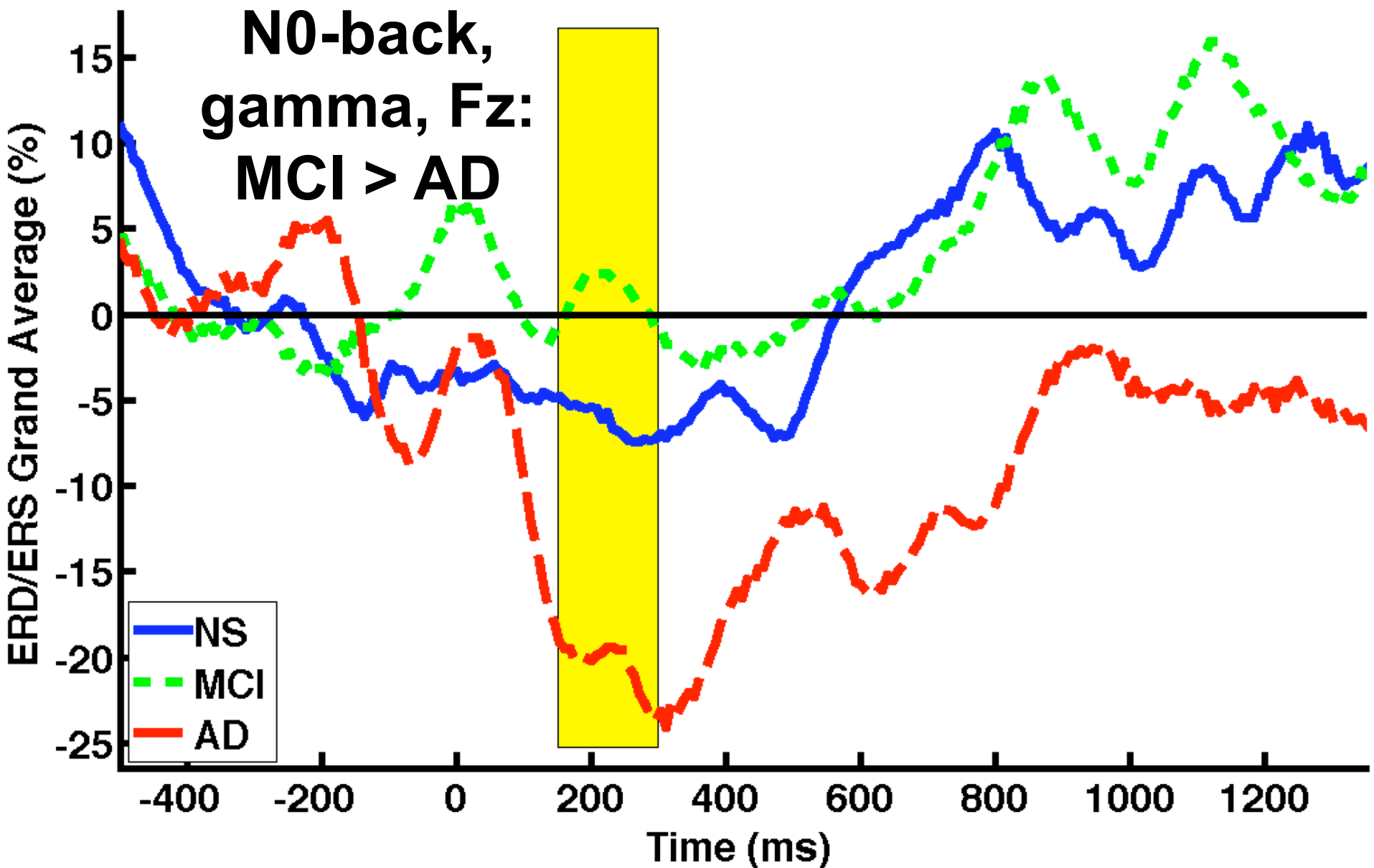
- ❑ **Random variable: ERD% (“cumulative ERDs”)**
 - ❑ sum of %ERD(t) over 150 ms intervals with 75 ms overlapp, from 75 ms to 1300 ms post-stimulus
- ❑ **p < 0.05, non-parametric Kruskal-Wallis test, Bonferroni correction (multiple comparison)**
- ❑ **ROI – 5 electrodes with greater %ERD “distance”**
 - ❑ Evaluated over all 150 ms intervals from the 4 bands

$$D(G_1, G_2) = \frac{|Med(G_1) - Med(G_2)|}{\sqrt{\sigma_1 \sigma_2}}$$

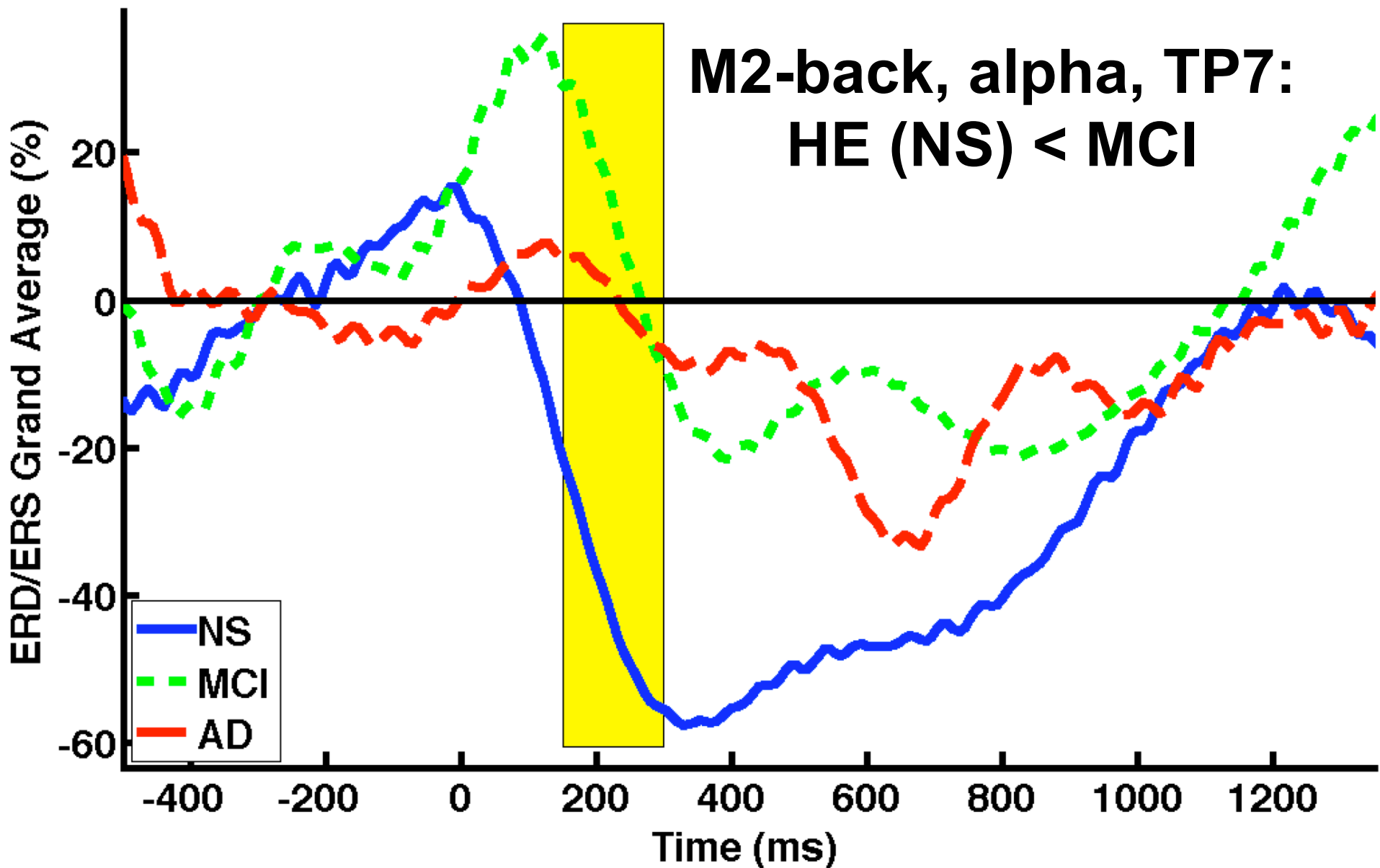
RESULTS (only trials with correct answers)

Task	Band	Electrodes	ERS% (-%ERD)
M1-back	beta	CP3, P3, TP8, P4	HE < MCI
M1-back	gamma	Fz	HE > MCI
M2-back	alpha	TP7, T5,	HE < MCI
M2-back	alpha	C3	HE < AD
N0-back	beta	C4, CP4	HE < MCI
N0-back	gamma	Fz	MCI > AD
N1-back	gamma	Fz	HE > AD
N2-back	beta	TP8	HE < MCI

RESULTS (only trials with correct answers)



RESULTS (only trials with correct answers)



Discussion and Conclusion

- Literature: alpha and beta rhythms present ERD in judgement and memory tasks (healthy people)
- Our %ERD results : HE < MCI < AD (HE **more** negat.)
- **Surprisingly, on gamma band at Fz we found just the opposite: HE > MCI > AD (HE less negative)**
- Literature: increase in task complexity and/or attention results in greater ERD (neg.) magnitudes
- Our results corroborate (↑memory load, ↑%ERD)
- We conclude that ERS/ERD responses to working memory (visual *N-back*) tasks could be useful for assessing the likelihood of MCI progression to AD