Alpha-Peak Parameters, 1/f Neuronal Noise, and Their Relation to Cognition in Elderly age

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Introduction

Aging is accompanied by:

- Decline of 1/f slope of the power spectral density (PSD)[1]
- Alpha peak frequency (IAF) slowing[2]
- Alterations of power in alpha (8 – 12 Hz) and slower frequency ranges (<7Hz)[2,3]
- Cognitive decline[2]

However, consistent evidence regarding age-related alterations in 1/f slope and slow wave power in the elderly population is lacking. It is also unclear how all of these measures relate to cognition.

Objectives

1. To investigate age-related alterations of *periodic* (i.e., theta power, alpha power, IAF) and *aperiodic* (1/f slope) components of the PSD in a big sample of elderly participants;
2. To investigate which of these PSD parameters relate to cognitive function;

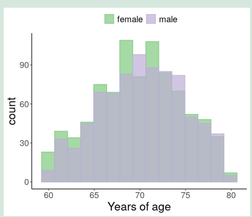
Dataset

A subset of the population-based LIFE-Adult dataset*

1703 elderly participants (M*age*= 70 ± 4.7, 880 female)

Resting-state EEG (rsEEG) :

- 31 electrodes
- 20min of eyes-closed rest



Cognition battery:

Stroop, Trail Making Test,

Wortschatztest, Wechsler's Memory Scale (Logic memory subscale)

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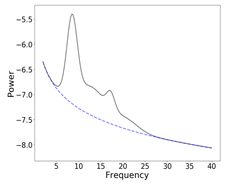
References

1. Haller, M., et al. (2018) „Parameterizing neural power spectra", bioRxiv
2. Knyazeva, M. G., Barzegaran, E., Vildavski, V. Y. (2018) „Aging of human alpha rythm", Neurobiology of Aging, Vol. 69, pp. 261-273
3. Vlahou, E. L., Thurm, F., Kolassa, I. T. (2014) „Resting-state slow wave power, healthy aging and cognitive performance", Sci Rep, Vol. 4, pp. 1-6

Methods

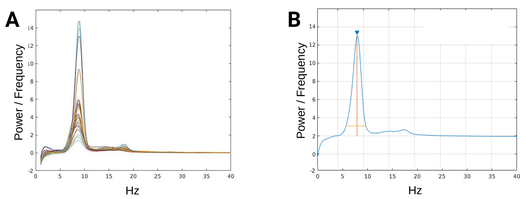
1. Preprocessing of the rsEEG data: 5 min of recordings with high vigilant state
2. PSD was estimated with Welch's approach (4s windows)

   Aperiodic part of the PSD was estimated using FOOOF toolbox [1] as $P(f) \sim 1/f^{\gamma}$, where γ is the slope of spectral decay



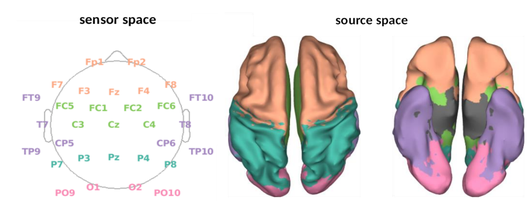
3. De-trending of the original signal (A)

   Peak search between 4 – 7 Hz and 7 – 13 Hz and estimation of the peak parameters (B)



4. 10 regions of interest (ROIs) defined at source space and 6 at sensor space for further statistical analyses

   Source analysis was performed with eLORETA



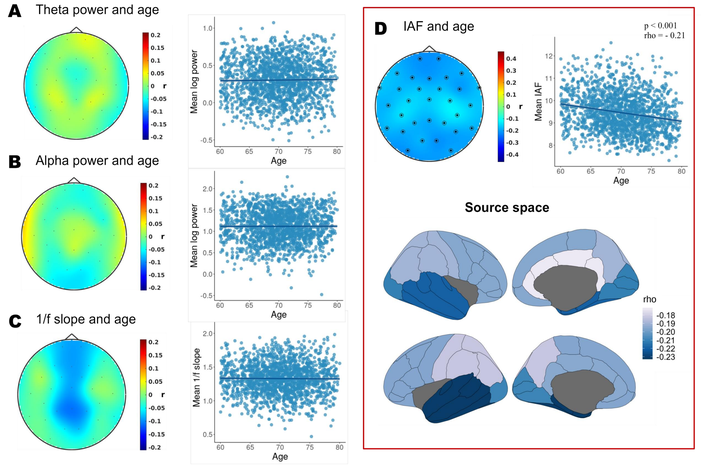
5. Factor analysis on the cognition battery: Promax rotation, number of factors determined by scree plots
6. Separate linear models (LMs) were used for each ROI to test differential relationship between EEG parameters and cognition (i.e. factors). Independent variables of interest were alpha power, theta power, IAF, 1/f slope, and their interaction with age. Age, sex and education were added as variables of no interest.

Results

1 Age-related alterations in EEG parameters

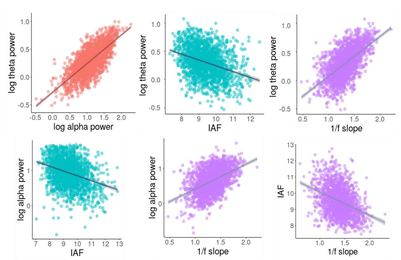
Our results show a negative association between individual alpha peak frequency (IAF) and age (p<0.001): IAF is decreased with increasing age and this effect is prominent in every cortical region with strongest alterations in the left temporal region.

We found no relationship between age and 1/f slope, alpha power, or theta power in our sample of elderly participants.

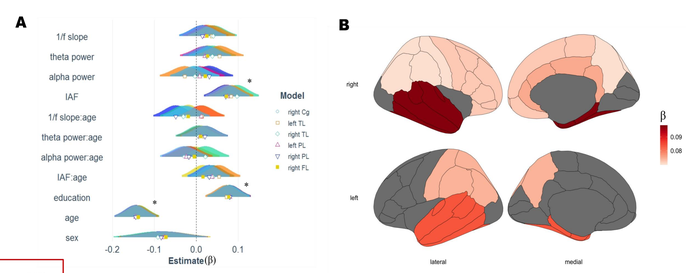


2 Correlation between rsEEG measures

Theta power, alpha power, IAF, and 1/f slope of the PSD are highly correlated.



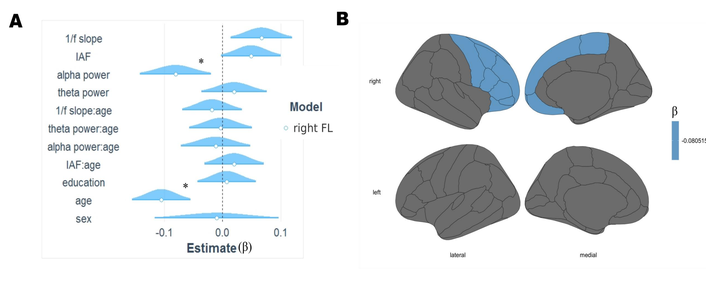
3 Individual alpha peak frequency and working memory



A positive association between individual alpha peak frequency (IAF) and the factor representing working memory (p<0.01): LMs show that higher IAF at the right and left temporal regions, but also at the bilateral parietal as well as right frontal region, and anterior cingulate cortex is related to a better working memory performance when all other EEG parameters, as well as age, sex, and education, are kept constant.

4 Alpha power and speed of processing

A negative relationship between alpha power in the right frontal region and the factor representing speed of processing (p<0.01): LMs revealed that reduced alpha power in the right frontal lobe relates to a faster speed of processing in the Stroop task when all other EEG parameters, as well as age, sex, and education, are kept constant.



Conclusions

- We replicated a prominent decrease in IAF with increasing age over the whole cortex
- No evidence for age-related alterations in 1/f slope, alpha power, and theta power when controlled for IAF and vigilance in the age range from 60 to 82 years
- IAF positively associated with working memory performance
- Reduced alpha power in the right frontal region is associated with a faster speed of processing in the Stroop task