No relationship between age an 1/*f* noise in 170 MEG datasets

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Abstract

Recent evidence points towards an increase in 1/*f* neural noise (noise with decreasing power in higher frequency bands) with age. Previous evidence related this increase to a decrease in working memory performance. Here, we attempted to replicate previous findings with a dataset from the Cam-CAN project ($N = 170$, aged 18-86). We used two minutes of a resting-state recording to estimate the power-spectral density of neural activity. We then correlated the slope of the noise curve with age ($r = -0.10$, $p = 0.194$), as well as short-term working memory ($r = 0.09$, $p = 0.230$). We were unable to replicate a previous increase in 1/*f* noise with age, as well as a relationship with working memory performance, indicating that an increase of 1/*f* noise is not a universal phenomenon and may be task-dependent.

Keywords: MEG; noise; ageing

Introduction

One feature of the power spectrum of human brain activity obtained through electrophysiological imaging is a decrease in power with increasing frequency. This relationship between power and the inverse of frequency (often described as 1/*f*, or pink, noise) has recently been linked to ageing (Voytek et al. 2015). Voytek and colleagues found that the linear relationship between frequency and noise was steeper in younger individuals, with less electrophysiological noise in high frequency bands. They were able to show this relationship using both intracranial electrocorticography (ECoG) and electroencephalography (EEG).

Interestingly, they were also able to demonstrate a relationship between the levels of 1/*f* noise and visual working memory, finding that 1/*f* noise mediates impairments of visual working memory in ageing.

Here, we wanted to replicate this finding and test its central hypoethis in a public dataset: the Cambridge Center for Ageing and Neuroscience data repository (Cam-CAN, Taylor et al. 2017). Recently released, this data repository contains resting-state MEG data from around 656 individuals aged 18–87. In addition, most of these participants performed a visual short-term memory (VSTM) task. We therefore tried to replicate the finding of 1/*f* noise increasing in age, as well as the relationship between 1/*f* noise and working memory performance.

Methods

Due to computational resources, we focused on an intial random subset of 170 subjects from the Cam-CAN Stage 2 release. These subjects had an average age of 54.7 years (st.dev.: 18.3, range: 18-86).

MEG recording methods are described in Taylor et al. (2017). Resting-state recordings lasted 8:40 minutes and were done with eyes closed.

All data analysis was performed using MNE-python (Gramfort et al. 2014, Gramfort et al. (2013)). We chose a random two-minute segment from the full recording. We performed temporal space-signal separation (tSSS, Taulu, Simola, and Kajola 2005, correlation threshold 0.98, 10-sec sliding window), followed by ICA decomposition and removal of ICA components based on the highest correlation with the HEOG, VEOG and ECG channels.

We then computed the power-spectrum density from 2 Hz to 7 Hz and from 14 Hz to 24 Hz, avoiding the alpha range (see Voytek et al. 2015), using Welch's method (2 s sliding window, 50% overlap). We log-transformed this powerspectrum and calculated a linear regression of this semi-log data for each gradiometer for each individual. Before statistical analysis, any electrodes in which the intercept of this linear regression was two standard-deviations above or below the average for an individual was removed.

We then calculated correlation coefficients between the slope of this linear regression and age as well as visual short term memory performance.

Results

There was no evidence for a relationship between 1/*f* noise slope and age ($r = -0.10$, $p = 0.194$). There was also no evidence for a relationship between 1/*f* noise and visual short-term memory ($r = 0.09$, $p = 0.230$).

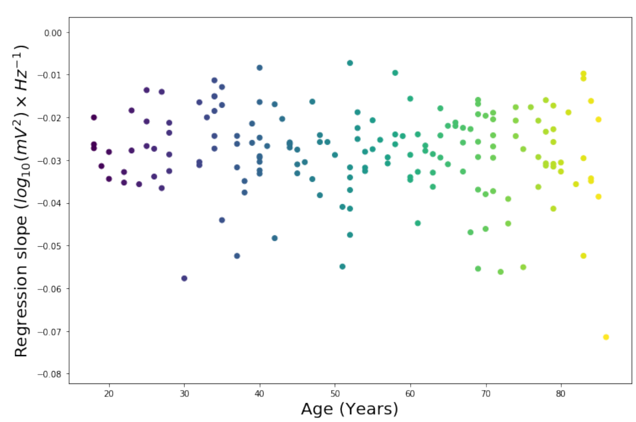

Figure 1: No relationship between 1/f noise and age.

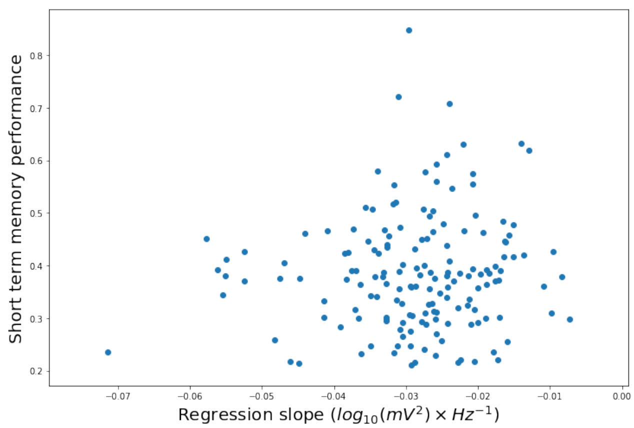

*Figure 2: No relationship between 1/*f *noise and VSTM.*

To visualise this further, we plotted the power spectrum between 2 and 24 Hz for the top and bottom age quartile of our sample, demonstrating that there is no overall difference in the power spectra, and that the linear fall-off of $\log_{10}$power with frequency is equivalent in the youngest and oldest age groups.

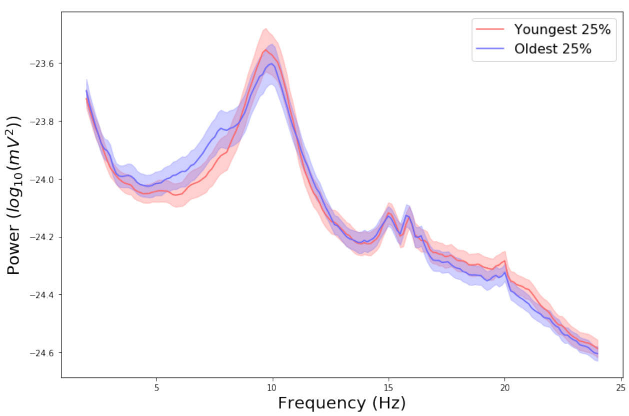

Figure 3: Equivalent power spectra in the top and bottom age quartiles.

Conclusions

While this analysis did not confirm previous reports of increases in 1/*f* noise with age, differences between this and previous studies limit the generalisability: this was resting-state data recorded with eyes closed, rather than task data. Behavioral states have been shown to modulate 1/*f* noise (Podvalny et al. 2015), so recording at rest may obscure task-relevant noise components. Additionally, we limited ourselves to a sub-sample of this dataset, both in the participants we included and in the time-period we analysed.

Additionally, we analysed a visual short-term memory task in analogy to previous work by Voytek at al. (2015). However, this task was in fact done separately to the MEG sessions, which likely contributed to the lack of relationship between the 1/*f* noise and task performance.

We therefore intend to repeat this analysis using the complete rest recording, and complete task recordings. We also intend to relate 1/*f* noise to performance on the task done during MEG recording, a sensorimotor task. However, we believe the current analysis contributes to our knowledge of 1/*f* noise components and their relationship to ageing.

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