Functional Connectivity within the Default Mode Network: The Effect of Epoch Length

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Introduction

In order to determine the Functional Connectivity (FC) between different brain regions, standard methodology uses scan durations of several minutes to calculate correlation strength. Recently it has been suggested that using shorter temporal intervals is viable, which could enable the study of dynamic changes in Intrinsic Connectivity Networks [1]. However, this could potentially compromise the reliability of FC measurements [2]. The aim of the current study was to investigate this potential confound by examining how the Default Mode Network (DMN) FC correlation strength was affected by varying the epoch length from 15 minutes to 8 seconds.

Methods

Subjects:
8 healthy subjects (5 male, age 32±6 years) underwent a 15 minutes resting fMRI scan

fMRI :
- 3 T Philips Achieva MRI Scanner with a 8-channel head coil
- Acquired resting scans; 3x3x4mm voxels, TR = 2000ms,450 volumes, flip angle 80°

Definition of the DMN

Data from a separate cohort of 55 subjects (28 male, age 25±4yrs) was used to define the DMN

- Using MELODIC in FSL, data were decomposed into 10 spatially independent components [3].
- Each component was divided into an individual node and ROIs defined as 5x5x5 voxel cube centred on the maximum z-statistic voxel for each node (*Fig 1*).

FC was measured between the Posterior Cingulate Cortex (PCC) seed region and all DMN ROIs (*Fig 1*) using six different epoch durations (filter 0.009-0.08Hz, global signal and white matter regression).

Epoch	Overlap
15 min	-
2 min	1 min
1 min	30 sec
30 sec	16 sec
16 sec	8 sec
8 sec	4 sec

For comparison, a simulated dataset was created by randomising the data timecourses.

Datasets were created for each of the different epoch lengths and compared to the FC data

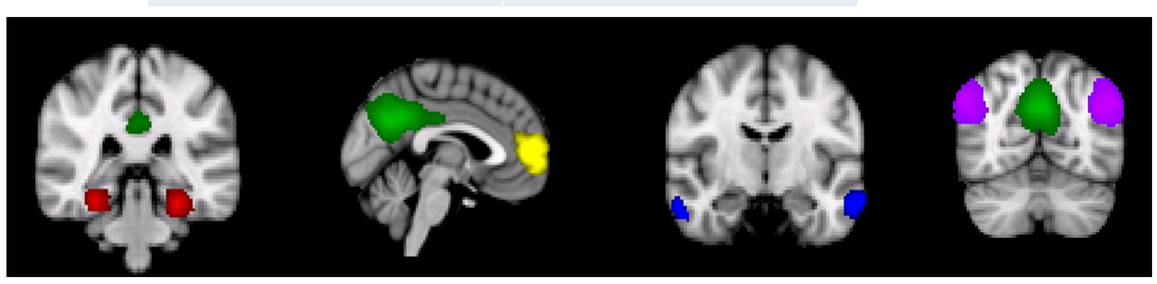

Fig 1. The DMN masks. PCC seed region in Green. lMTL/rMTL in Blue, mPFC in Yellow, lIPC/rIPC in Purple, lPHP/rPHP in Red.

Results

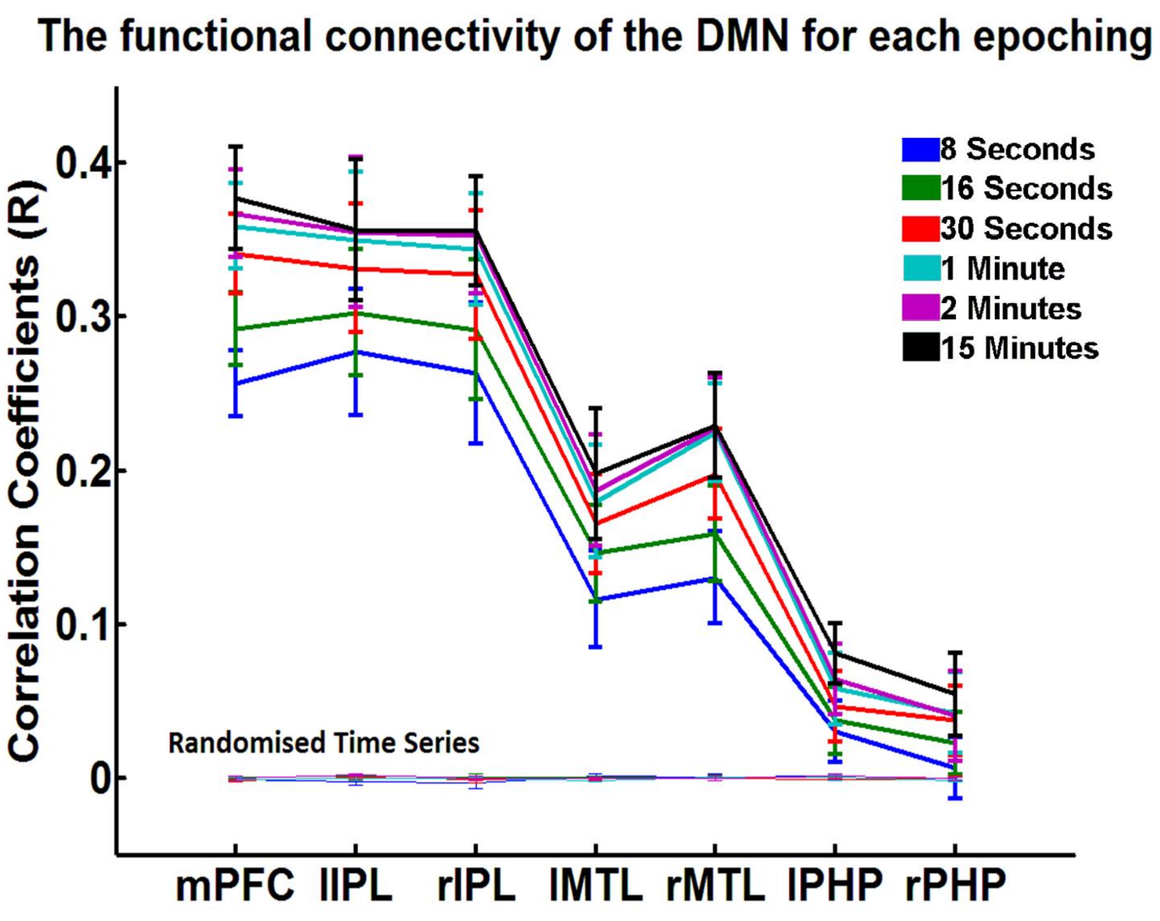

Fig 2. FC strength between the PCC seed ROI and the DMN for each epoch length (solid coloured lines) compared to Randomised Time Series. Errorbars represent the group mean ± SE.

- A similar pattern of average FC was observed across DMN for all epoch lengths. However, the FC strength decreased as the epoch length decreased (*Fig 2*).
- Reduction of 45.1% from 15min-8sec on average across DMN (*Fig 2*).
- A two-way ANOVA (Epoch, Region) showed significant main effects of Epoch ($p<0.001$) and Region ($p<0.001$) with a significant interaction between Epoch and Region ($p=0.001$).
- In high FC regions (mPFC, lIPL, rIPL), epochs of 30sec were not significantly different to the 15min scan (*Fig 2*).
- The DMN was robustly identified even with short epochs (*Fig 3*).

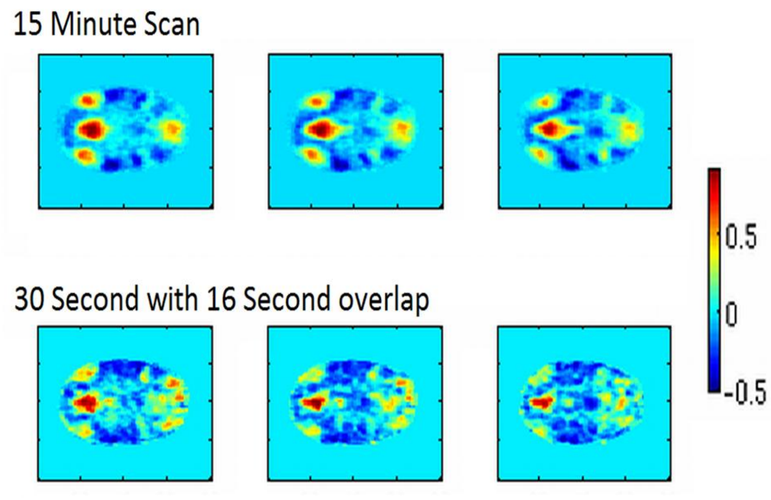

Fig 3. Axial slices showing the average FC correlation. Red/yellow colours indicate high FC and light blue approximately zero FC. Axis labels indicate voxel dimensions. The left/right side of each image represents the posterior/anterior direction in the brain respectively.

Discussion

FC is generally quantified using data epochs of several minutes, but it is becoming increasingly clear that assessing the contribution of dynamic changes in FC can have considerable power in explaining response and behavioural variability [4,5].

In this study, FC of the DMN was assessed as a function of epoch length to investigate whether simple correlation analyses can quantify dynamic changes in RS connectivity. In general, the FC strength within the DMN remained consistent across epochs (*Fig 2*), although some significant differences emerged when using 30 second and shorter epochs in some regions with lower connectivity.

Conclusion

When using 30 second epochs, the DMN was reliably identified and FC was significantly different from the random datasets. Our results show that FC could be analysed using a sliding window as short as 30 seconds without the risk of spurious correlations.

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