Stationarity during REM sleep in Old Adults

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Introduction

Rapid Eye Movement (REM) sleep exhibits a low voltage mixed frequency electroencephalogram (EEG), muscular atonia and REMs [2]. Usually, EEG signals are assumed to be non-linear and non-stationary and no testing is performed, particularly in Old Adults (OA) sleep registers. The aim of this research was to compare the proportion of stationarity of REM sleep vs non-REM (NREM) sleep and wakefulness (W). Stationarity was analyzed using the Priestley-Subba Rao (PSR) test. We also explored if this tool can be used to detect the traditional indicators of sleep stages along the sleep recording, focusing especially in REM sleep.

Methods - Subjects

Five OA [age: 68.2 ± 7.2; education: 9.2 ± 2.7] without depression neither anxiety and with intact daily living activities were selected. They were evaluated with the Mini-Mental State Examination (MMSE, 29.4 ± 0.9). Also, a one night polysomnography (PSG) was performed. From those recordings, epochs of 30 seconds were classified according to the American Association of Sleep Medicine (AASM). Finally every epoch of W, NREM and REM sleep was filtered and subjected to the PSR test.

Priestley-Subba Rao (PSR) test

The test introduced by Priestley and Subba Rao [3,4], estimates the spectrum of the signal and then tests it with the hypothesis "spectrum does vary over time" -which is equivalent to test non-stationarity. Prior to that, deterministic trends are removed from the signals by applying the algorithm 'Seasonal-Trend decomposition using Loess' [1].
Percentages of stationary epochs were calculated for each subject and stage, and Wilcoxon t-tests were used to compare them.

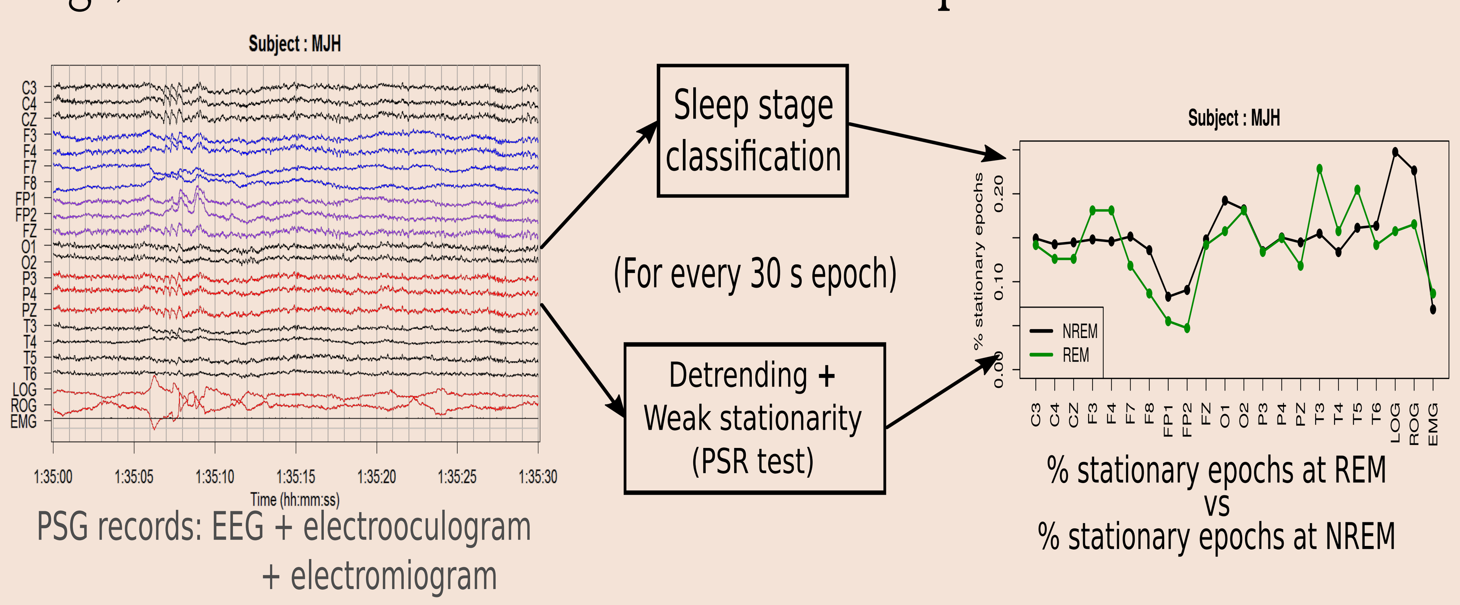

Figure 1: Diagram of the method. PSG of one 30 s epoch for an OA (left). REM sleep is classified by AASM standards, signals are filtered and weak stationarity is detected using PSR test (center). Comparision of percentage of stationary epochs at REM (green) and NREM (black) of an OA (right).

Results

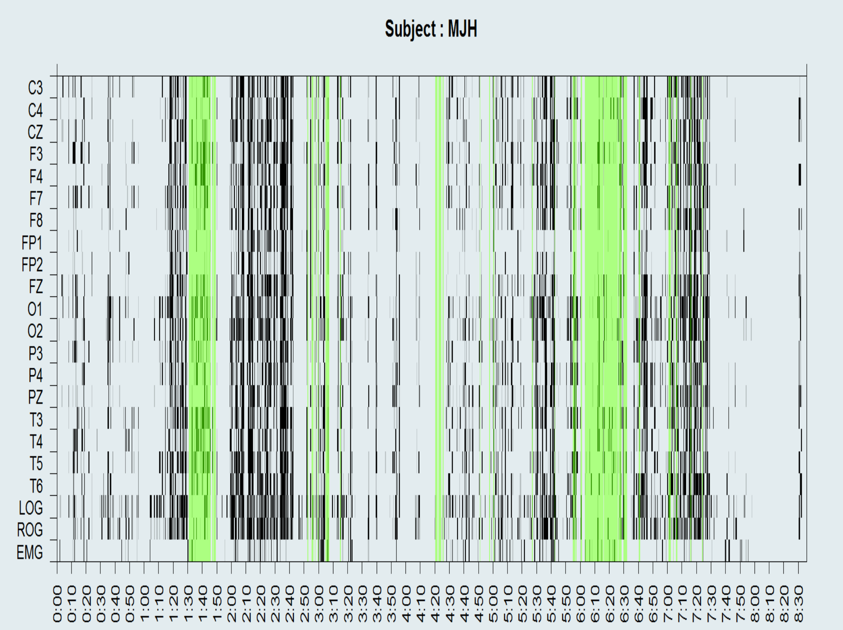

Figure 2: Distribution of stationary epochs (black) over time of an OA. REM sleep is shown in green.

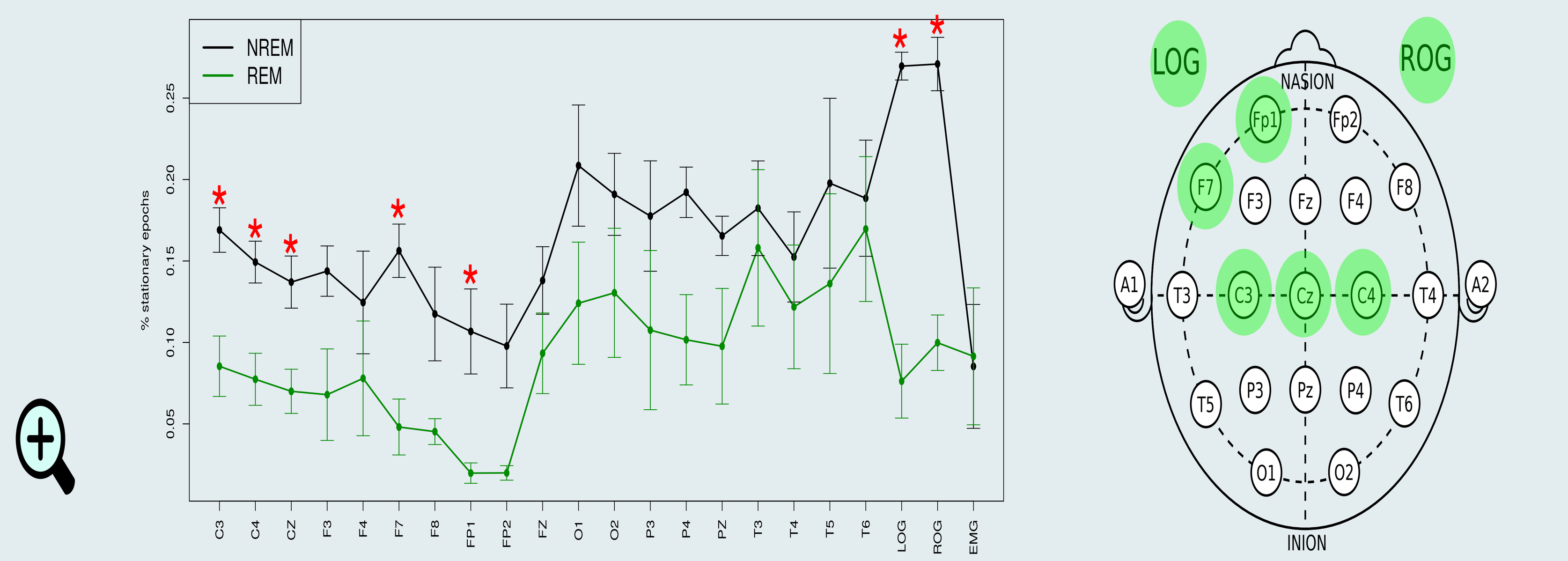

Figure 3: Mean and standard deviation (left), for the percentage of stationary epochs calculated over REM and NREM sleep. Asterisks represent significative differences found using paired one-tailed Wilcoxon t-tests. Diagram representing the areas where significant differences were found (right).

The PSR test effectively showed different proportions of stationary epochs, according to the classification of REM sleep stages in each subject. In Figure 2, for one OA, stationary epochs are shown in black and the classification of REM sleep is shown in green. Clearly, a lower proportion of stationarity was found in REM sleep vs the other stages. These differences reached significance in C3, C4, CZ, F7, Fp1, LOG, ROG (p<0.05, Figure 3)

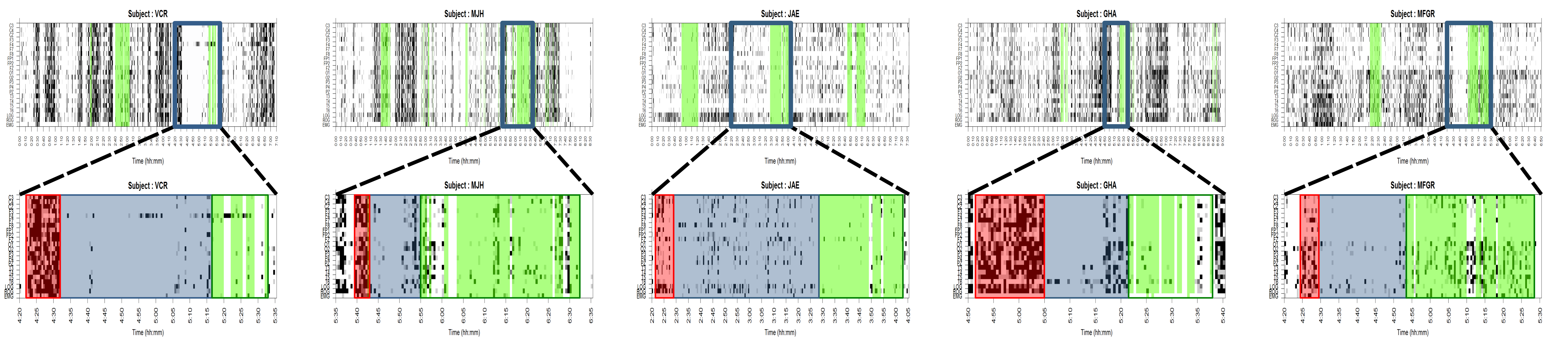

Figure 4: Distribution of stationary epochs for all 5 subjects, highlighting the found pattern, which is associated with REM sleep. Epochs corresponding to the full register (Up). Zoom over the patterns, highlighting details of them: a 'block of stationarity' (red) a 'block of non-stationarity' (blue) and a block containing REM sleep (green) (down).

Conclusions

In OA, REM sleep showed lower proportions of epochs with weak stationarity, compared to W and NREM sleep, at frontal left and central areas and in both electrooculograms, a result that could be explained by the REM sleep characterization. The graphic method described seems to be a suitable way to detect REM sleep in OA.

Acknowledgments

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