EEG MICROSTATE FEATURES OF CYCLIC ALTERNATING PATTERN (CAP)

Angelica Quercia[1], Pierpaolo Croce[2], Angelo Quartarone[3], Filippo Zappasodi[2,4]

[1] University of Messina, Messina, Italy

[2] "G. d'Annunzio" University of Chieti-Pescara, Chieti, Italy

[3] IRCCS Centro Neurolesi Bonino Pulejo, Messina, Italy

[4] Institute for Advanced Biomedical Technologies (ITAB), Chieti, Italy

INTRODUCTION

EEG microstates capture rapidly alternating activity of distributed cortical networks as scalp potential topographies that dynamically vary over time in an organized manner[1]. Wakefulness and NREM sleep have been found to share typical maps of EEG-microstates[2], even though microstate features were very similar only for wake and stage N1. Sleep stage N2, instead, differed in all parameters from the other stages and all microstate map duration increased significantly in N3[2]. Moreover, different microstates characterized periods of NREM sleep on the basis of content (dreaming versus non-dreaming) [3]. Beyond conventional sleep stages scoring, the dynamic structure of sleep could be described by Cyclic Alternating Pattern (CAP), physiological state of sleep instability that reflects arousals of different intensity and morphology organized in sequences[4]. Here we aimed to investigate microstate features in CAP sequences of healthy subjects.

METHODS

Polysomnographic recordings (PSG) of 14 healthy subjects (age mean ± SD: 32.57 ± 5.44 years, 7 F and 7 M) was used to perform microstate analysis. EEG recordings, available in the CAP Sleep Database (https://physionet.org/content/capslpdb/1.0.0/), included at least 3 EEG channels (F3 or F4, C3 or C4 and O1 or O2, referred to A1 or A2), EOG (2 channels), EMG of the submentalis muscle. The scoring of the sleep macrostructure and microstructure (CAP) was performed by expert neurologists. Microstates maps and features were separately extracted for each CAP sequence, phase A (A-CAP) and B (CAP), NO-CAP periods of NREM sleep. Subsequently, microstates were compared across conditions. Moreover, a partial least square regression analysis was performed to evidence the relationship between microstates and CAP.

RESULTS

Four microstate maps were found, resampling those obtained in previous studies (A, B, C and D). A-CAP (193 ± 18 ms) microstate D duration was longer than both B-CAP (184 ± 14 ms) and NO-CAP duration (183 ± 18 ms), **Fig.1A** . A-CAP (35 ± 9 %) microstate D coverage was higher than both B-CAP (33 ± 9 %) and NO-CAP coverage (30 ± 9 %), **Fig.1B** . The regression model succeeded to show the predictive value of microstates features in inferring the CAP phases ($r = 0.55$, $p < 0.001$) **Fig.2A** . The weights of the model show that the highest predictability is due to the features of microstate D **Fig.2B.**

Fig.1

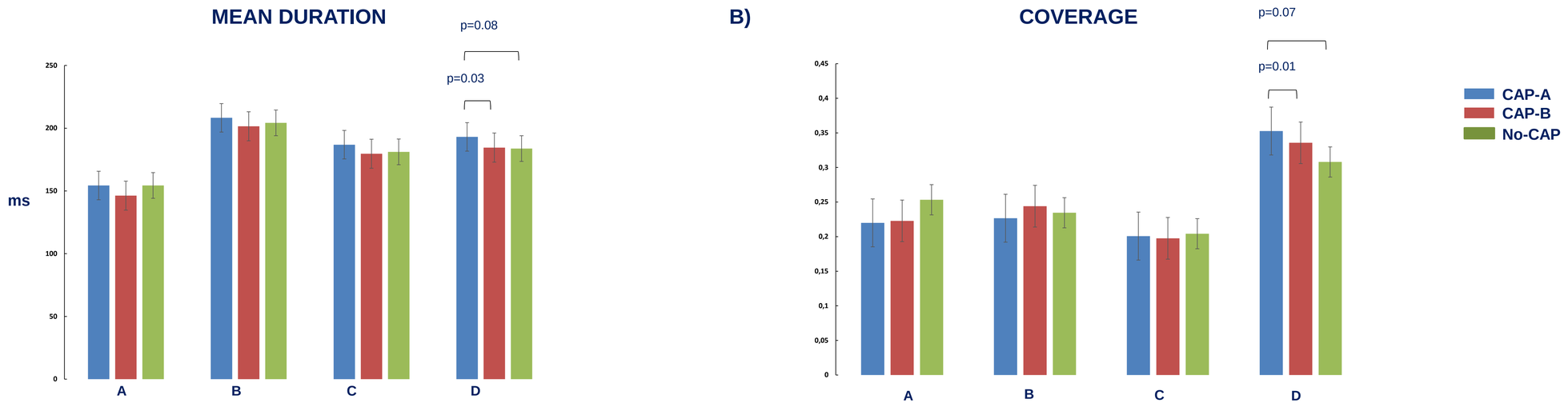
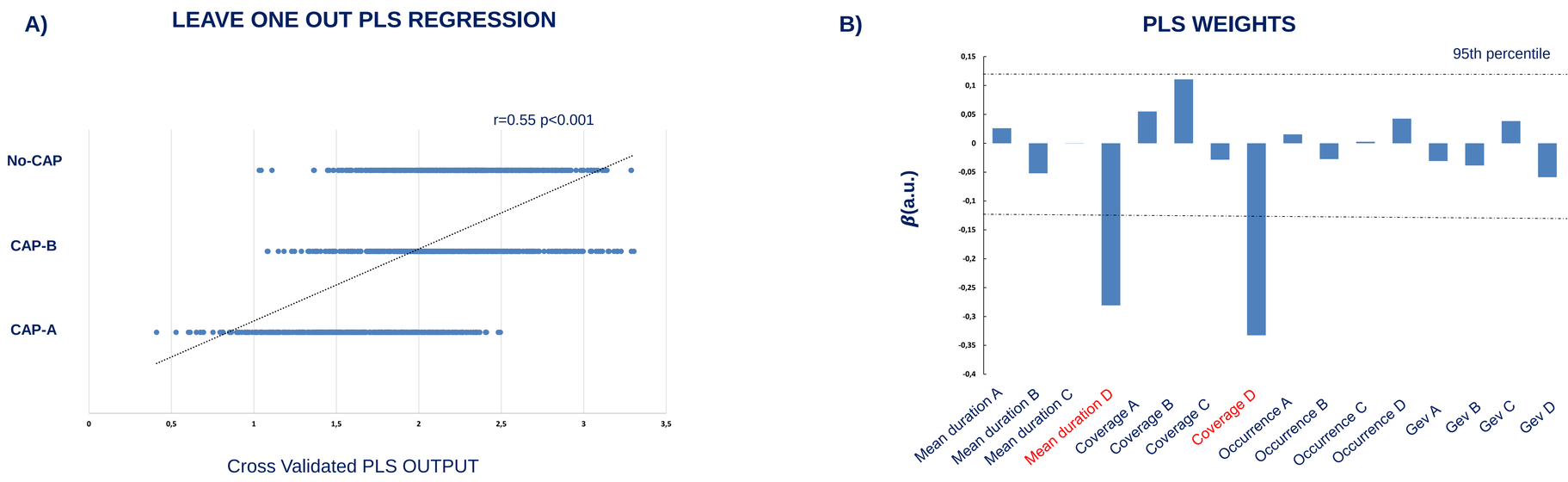


Fig.2



CONCLUSION

Overall, our findings demonstrate that the dynamic organization of sleep, characterized by the alternation of CAP (A and B phases) and NO-CAP sequences can be well described by the microstate features, that in fact represent the spatiotemporal brain dynamics. Interestingly, the highest predictability of the PLS regression model depends on the weights of microstate D, specifically on duration and coverage features. Moreover, duration and coverage of microstate D increase compared to B phases of CAP and NO CAP sequence. At macrostructure level, it has been found that Map D duration decreased with deepening sleep[2], especially in N3, explained as an increase in microstate stability. Therefore, our results support the relevance of CAP as physiology pattern of sleep instability.

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CONTACT : angelica.quercia@gmail.com

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