Why sparse bump models?

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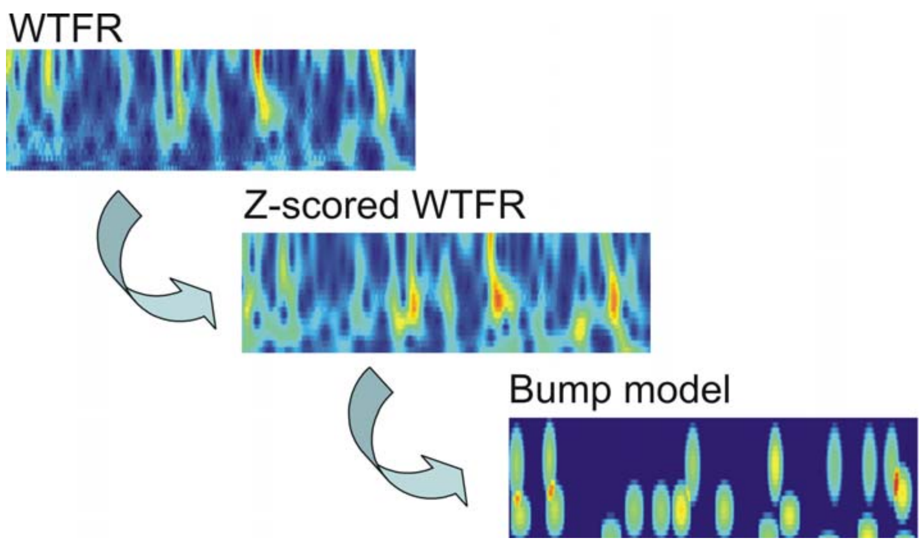
Introduction

Electroencephalography (EEG) is a useful brain imaging technology, because of its efficient time resolution. Several studies used of wavelet time-frequency representations (WTFR) in order to extract event-related EEG activities. However, WTFR describes the signals with thousands of coefficients; the information is blurred with non specific activity, which complicates discriminative analysis. We advocated in our previous publications (1) the use of bump modeling (sparsification method: patterns of high magnitude, lasting nearly 4 time periods of a specific frequency location) of time-frequency maps, in order to extract and enhance significant EEG information. This method allowed us to improve signal analysis, by accessing EEG prominent activities on a trial-by-trial basis; which in turn allowed us to access reliably specific signatures in LFP and EEG signals (1,2). We believe that such prominent activities are likely to represent transient local synchronization of neuronal assemblies, conveying key information on higher order cognitive and sensory processing. The purpose of the present report is to check how bump activities differ from background EEG.

Methods

We used here a database with 22 patients in the early stage of Alzheimer's disease (mild cognitive impairment or MCI) and 38 control subjects. In the course of a clinical study, EEG was recorded in rest condition, with eyes closed, 21 electrodes and a sampling rate of 200 Hz; the database is described with more details in (3). EEG signals were first transformed into WTFR maps; afterwards the high magnitude patterns were extracted using bump modeling (**Fig.1**). We assessed EEG traits using the WTFR maps relative power, by computing a linear classification in four different frequency bands: theta (3.5-7.5 Hz), $alpha_1$ (7.5-9.5 Hz), $alpha_2$ (9.5-12.5 Hz), and beta (12.5-25 Hz).



Results and Discussion

We found the most significant differences in the theta and beta range (Mann-Whitney test $p<0.01$). We compared the WTFR relative power in all four frequency ranges, before and after bump processing (**Fig.2**). The difference in theta range was enhanced by bump modeling ($p=10^{-4}$ instead of 0.08), while the beta range difference was reduced.

In order to understand why beta range difference was reduced, we checked for correlations between theta and beta range activity before and after bump modeling (**Fig.3**). Before bump modeling, there are no such correlations, both for MCI and control groups (Pearson test $p>>0.10$). Interestingly, after bump modeling a strong correlation appears between activity in the theta and beta oscillatory burst in the control group (Pearson test $p<0.01$). In other words, this means that low and high frequency oscillatory burst share some common traits, while the background activity is dissociated. This effect disappears for MCI subjects (Pearson test p slightly above 0.10).

Conclusion

These observations confirm our hypothesis: EEG background activity displays a functional decorrelation with EEG peak oscillatory activities, which can be retrieved by bump modeling.

References

(1)Vialatte FB, et al. (2007) Neural Networks 20:194-209.
(2)Vialatte FB, et al. (2005) LNCS 3696:683-692.
(3) Woon WL, et al. (2007) Physiological Measurement 28:335–347.