A unique temporal, spatial, and spectral description of the working memory oscillatory dynamics

Chiara Rossi, Diego Vidaurre, Lars Costers, Marie B. D'hooghe, Miguel D'Haeseleer, Guy Nagels, Jeroen Van Schependom

VRIJE UNIVERSITEIT BRUSSEL

AIMS AI-SUPPORTED MODELLING IN CLINICAL SCIENCES RESEARCH GROUP

BACKGROUND

The brain dynamics underpinning working memory (WM)[1,2] :

1. unfolds at milliseconds (ms) time scale,
2. recruites large-scale brain networks,
3. involves different (ϑ, α..) brain rhythms.

Traditional investigations assess only one or two dimentions and/or are limited in the time-frequency resolutions[2].

How can we optimally explore the rich temporal, spectral, spatial dimensions of the WM brain networks?

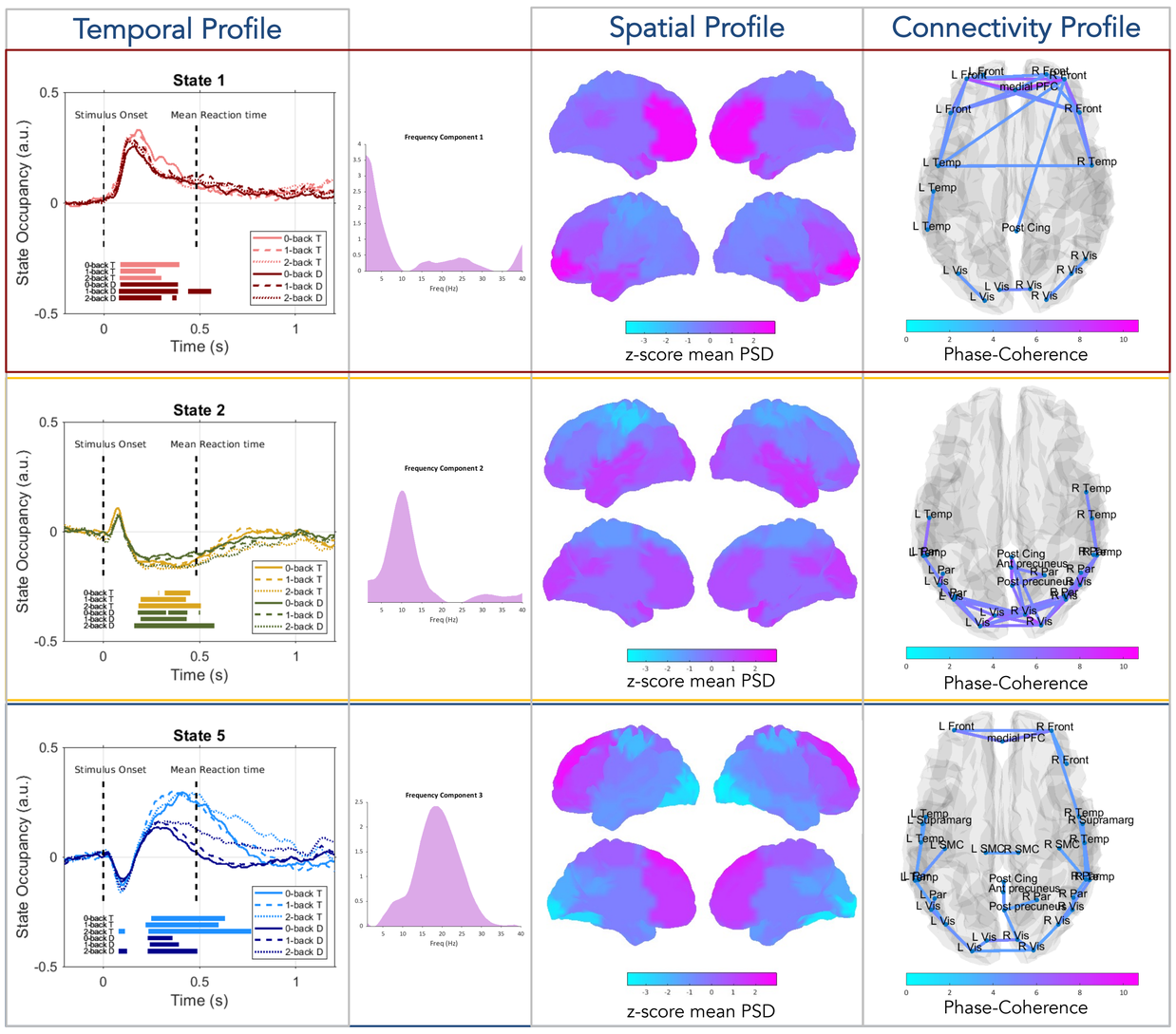
RESEARCH FRAMEWORK

This study optimally assesses the WM brain dynamics:

1. We acquire magnetoencephalographic data (MEG)
   → ms temporal resolution
2. We conduct a data-driven network analysis
   → time delay embedded-HMM (TDE-HMM)[3]
3. We extract data-driven frequency components, by non-negative matrix factorization (NNMF), in which we describe the brain networks[3]:
   →Mean power spectral density distribution
   →Phase-coherence connectivity map

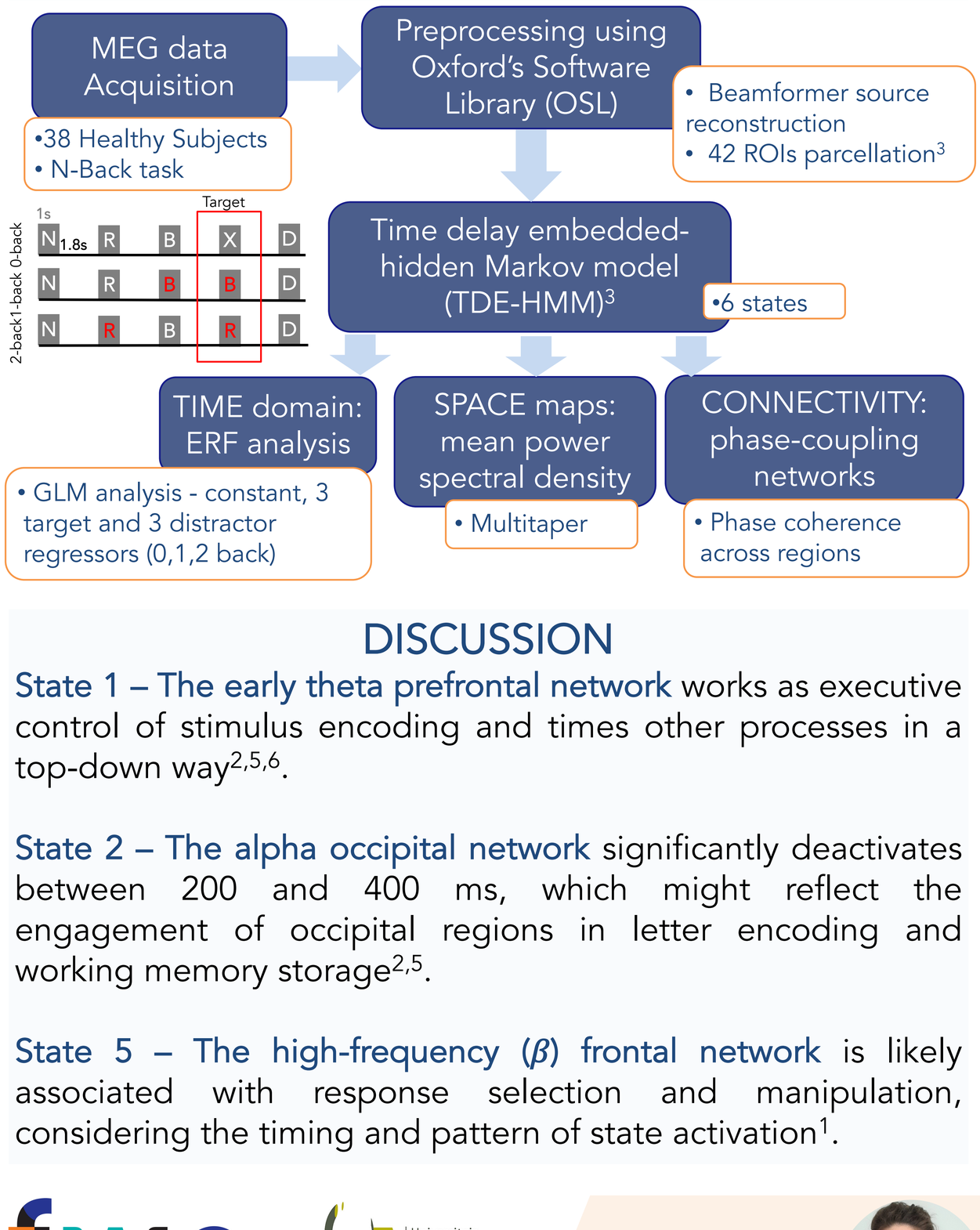
By applying the TDE-HMM on MEG data, we provide a novel description of the network dynamics underlying WM at milliseconds resolution

RESULTS



STATES' PROFILES. Every row of this figure shows one state. From left to right, the plots show the temporal, spatial and connectivity profiles of each state. The spatial maps plot the normalized average power spectral density across the 42 parcels, and the connectivity networks display the phase coherence across brain regions; both quantities refer to a specific frequency component (mode) of the spectrum.

METHODS



DISCUSSION

State 1 – The early theta prefrontal network works as executive control of stimulus encoding and times other processes in a top-down way[2,5,6].

State 2 – The alpha occipital network significantly deactivates between 200 and 400 ms, which might reflect the engagement of occipital regions in letter encoding and working memory storage[2,5].

State 5 – The high-frequency (β) frontal network is likely associated with response selection and manipulation, considering the timing and pattern of state activation[1].

REFERENCES

1. Piccoli T, et al. (2015) The default mode network and the working memory network are not anti-correlated during all phases of a working memory task. *PLoS One*.
2. Costers L, et al. (2020) Spatiotemporal and spectral dynamics of multi-item working memory as revealed by the n-back task using MEG. *Hum Brain Mapp*.
3. Vidaurre D, et l. (2016) Spectrally resolved fast transient brain states in electrophysiological data. *Neuroimage*.
4. Oxford Centre for Human Brain U.K. Oxford's Software Library - OSL.
5. Riddle J, et al. (2020) Causal Evidence for a Role of Theta and Alpha Oscillations in the Control of Working Memory. *Curr Biol*.
6. Syrjälä J, et al. (2021) Decoding working memory task condition using magnetoencephalography source level long-range phase coupling patterns. *J Neural Eng*.

fwo ETRO ELECTRONICS & INFORMATICS

Universitair Ziekenhuis Brussel

National MS center Melsbroek

chiara.rossi@vub.be