Reliability and variability of the P3 network configuration revealed by multi-resolution source-space analysis

A. J. Privitera [1] & A. C. Tang [1,2]

[1] The Laboratory of Neuroscience for Education, Faculty of Education, the University of Hong Kong & [2] The MIND Research Network, Albuquerque, NM, USA

INTRODUCTION

Development of robust neuromarkers for individual differences in health and disease is important for basic and clinical research as well as for diagnosis and treatment[1].

One neuromarker, the P300 (P3) component of the event-related potential (ERP), has been extensively studied in clinical and non-clinical populations[2].

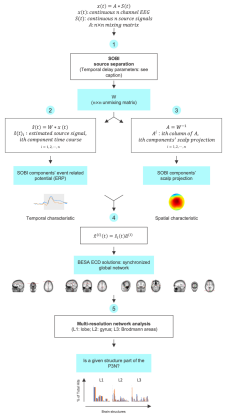
Beyond ERP analysis, quantitative characterization of the spatial configuration of this network may offer additional information for describing individual differences.

A common practice for anatomical labeling is reporting the nearest grey matter structure; this may lead to some potentially relevant structures being left out.

We present a method of hits-based analysis for quantitatively characterizing the spatial configuration of the network of generators underlying the well known P3 component (P3N).

METHODS

Participants: 13 participants (6 males) between 19 and 33 years of age (M = 26.50 ± 4.48 years).
Behavioral Task: 2-stimulus color visual oddball task (20% rare; 250 trials total; button press response to rare stimuli).
EEG Data Acquisition and Processing: 64-channel reference free EEG data sampled at 1000 Hz and bandpass filtered between 0.1 and 200 Hz and notch filtered at 50 Hz.
Blind Source Separation: Components extracted using second order blind identification (SOBI)[3] and P3 components identified based on spatial and temporal criteria[4-5] (see right).
Source Localization: Estimation of underlying generators using BESA, starting with a 4 pair bilaterally symmetric equivalent current dipole (ECD) template, based in part on earlier work[5].



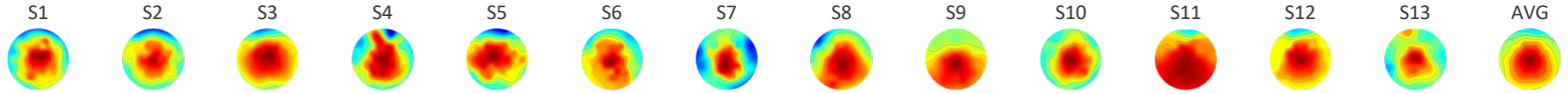
Anatomical Labeling: For all ECD coordinates, Talairach Client[6] was used to look up (A) names of structures contained within a cube of 11 mm^3 (ECD at the center) and (B) the numbers of 1mm^3 volume associated with each structure (defined as hits). Only grey matter hits were considered.
Dependent Variables:

- Probability of a structure being observed across participants, defined as the proportion of participants with at least 1 hit in a given structure;
- The % contribution of a structure made to the P3N within a participant, defined as the number of hits per structure / total hits from all structures within the P3N.

Statistical Analysis: Binomial and Wilcoxon signed-rank tests (1-tailed).

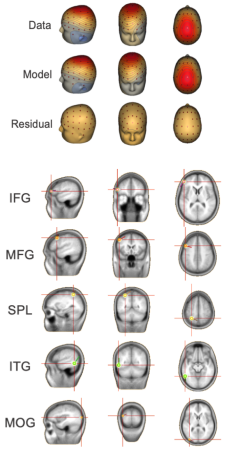
RESULTS

1. Reliable identification of SOBI P3 component in individual participants

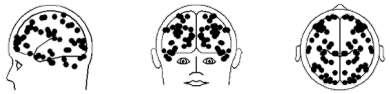


2. Localization of individual SOBI P3 component as a distributed network of ECDs

From a single participant (S10)

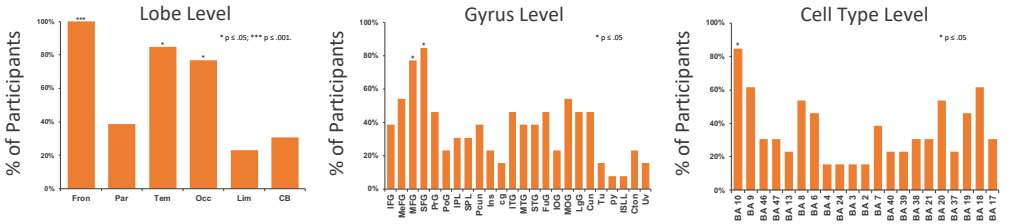


Cross-participants

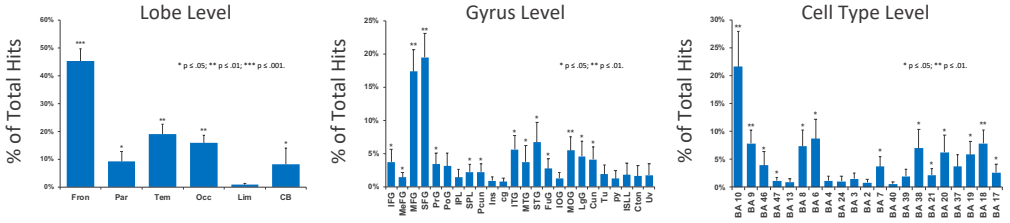


- N-pair ECD solutions: 4-5 pairs.
- GoF: 97.69% +/- .38%.
- Broadly distributed in all lobes of neocortex.
- No obvious focal clustering.

3. High cross-participant reliability of frontal lobe structures in contrast with high variability of remaining structures



4. Quantitative characterization of P3N spatial configuration highlights distinct contribution of frontal structures



DISCUSSION

Methodologically, we show that cross-participant reliability of each structure's involvement in the global P3-related network and the within-participant contribution of each structure to this network can both be quantified at multiple levels of spatial resolution.

Scientifically, we show that frontal structures, particularly the SFG, MFG, and BA10, are reliably involved across individuals and make the greatest contribution to the global network in comparison with less reliable non-frontal structures. This suggests a unique role of frontal structures in the global synchrony of neural activity.

REFERENCES

1. Lydiard J, Nemeroff CB (2019): Biomarker-Guided Tailored Therapy. *Frontiers in Psychiatry:* Springer, pp 199-224.
2. Polich, J. Neuropsychology of P300. In Handbook of Event-Related Potential Components; Luck, S.J., Kappenman, E.S., Eds.; Oxford University Press: Oxford, UK, 2012.
3. Belouchrani A, Abed-Meraim K, Cardoso JF, Moulines E (1993): Second-order blind separation of temporally correlated sources. *Proc Int Conf Digital Signal Processing:* Citeseer, pp 346-351.
4. Tang AC, Sutherland MT, Yang Z (2011): Capturing "Trial-to-Trial" Variations in Human Brain Activity. *The Dynamic Brain: An Exploration of Neuronal Variability and Its Functional Significance*. 183.
5. Zhang Y, Tang AC, Zhou X (2014): Synchronized network activity as the origin of a P 300 component in a facial attractiveness judgment task. Psychophysiology. 51:285-289.
6. Lancaster JL, Woldorff MG, Parsons LM, Liotti M, Freitas CS, Rainey L, et al. (2000): Automated Talairach atlas labels for functional brain mapping. *Human brain mapping.* 10:120-131.

We thank Drs. E. Tsang & R. Sun, E. Hua, R. Fung, and XY Niu for their assistance.