Task-induced high-gamma suppression shows lateralized relationships with reaction time in the retrosplenial cortex.

Weaver KE[1,5]; Wander JD[2]; Sarma D[2]; Blakely TM[2]; Johnson LA[3]; Grabowski TJ[1,4,5]; Ojemann JG[3,5]

(1) Dept. of Radiology, (2) Dept. of Bioengineering, (3) Dept. of Neurosurgery, (4) Dept. of Neurology, (5) Integrated Brain Imaging Center, University of Washington, Seattle, WA 98195

Introduction

Task-induced default mode network (DMN) deactivation is a well-established phenomenon with numerous imaging studies noting strong negative associations between the degree of deactivation and variable behavioral performance parameters such as reaction time (RT - Anticevi et al., 2012). The electrophysiological dynamics, however underlying this effect have received significantly less attention (Dastjerdi et al., 2011; Ossandon et al., 2011). We used electrocorticography (ECoG) to record electrical responses directly from the cortical surface while subjects completed a standardized language paradigm, requiring abstract-concrete discrimination.

Methods

We acquired ECoG signals from 7 epilepsy patients undergoing long-term monitoring for seizure focus localization. Experimental recordings were performed at the patient's bedside with g.USBamps (GugerTec, Graz, Austria) sampled at 1200 Hz and recorded with respect to an epidurally placed reference and ground electrodes.

EcoG signals were first manually inspected for artifacts and/or significant noise. All signals were then re-referenced with respect to the common-average of the remaining montage and notch filtered for 60, 120, and 180 Hz to eliminate line noise, using a fourth-order Butterworth filter.

Two spectral decomposition approaches were utilized.

1) Time-varying spectral (Time-Frequency) estimates were calculated using a continuous wavelet decomposition in MATLAB, utilizing complex Morlet wavelets .
Each analysis was conducted on time-X-trial event matrices based event boundaries for both rest epochs and language discriminations. Time-frequency estimates were calculated on broadband signals from 1-199 Hz with wavelet center frequencies stepped every 3 Hz. The magnitude of the complex wavelet coefficients for each time and frequency combination represented the spectral power estimate at that point. To account for the exponential shape of the spectra, spectral estimates were normalized on a per-frequency basis by subtracting the mean of all samples within the rest epoch and dividing by the standard deviation of those samples. The wavelet analysis was used to illustrate temporospatial distribution of responses across electrodes over the posterior-medial DMN sites.

2) To delineate task-based suppression, we concentrated on high gamma (HG; 70-200 Hz) power, a correlative marker of local cortical activity. Signals were band-pass filtered for the HG band. Instantaneous amplitude of the filtered signal across channels was estimated by taking the absolute value of the Hilbert transform. Data were squared to calculate continuous HG power and then log transformed to approximate a normal distribution (henceforth referred to as HG power) for the full time series.

Research reported in this abstract was supported by the grant NIMH, NINDS and the OD of the National Institutes of Health under award number 5ROI NS065186-035, MH086118-03 & 1 RC4 NS073008 01, respectively.

Figure captions

Figure 1. ECoG signals were reocrded during a cued abstract-concrete discrimination. Subjects were presented with a single word/trial and asked to determine whether the item was a real object or an abstract concept (Binder et al., 2005). Spectral estimates were segmented from the 1000 ms period prior to the onset of the trial and the 1000 ms prior to response (e.g. red box).

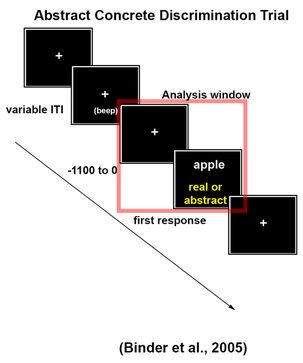
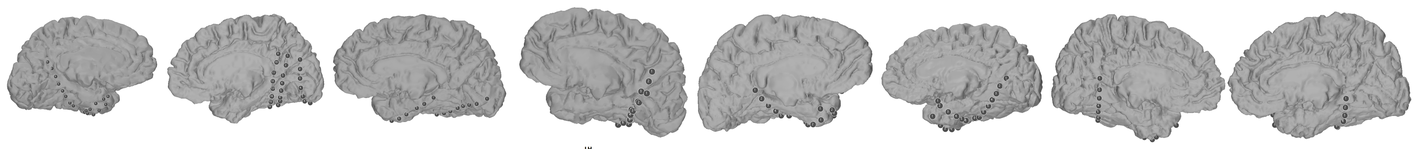


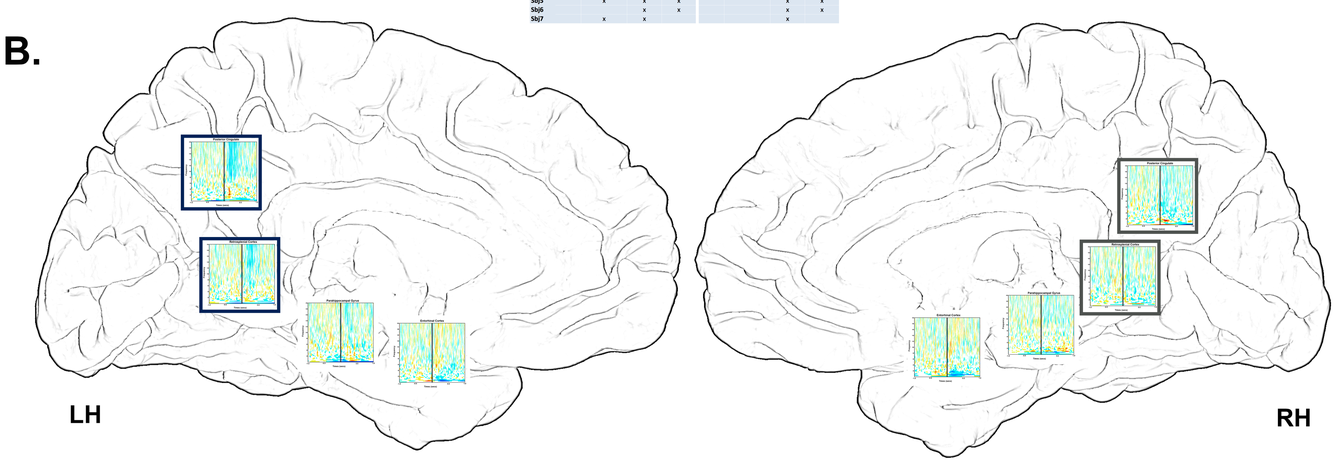
Figure 2. Association between DMN ECoG spectral estimated and language performance A) Shows the distribution of electrode coverage across subjects. Our analyses were focused on electrodes spanning medial parietal and temporal DMN sites, including the posterior Cingulate (PCC), the retrosplenial cortex (RSC), the parahippocampal gyrus (PHG) and the entorhinal cortex (ERC). B) selected TF plots reveal task-based HG suppression. There was a more pronounced suppression localized to the left hemisphere relative to the right, an effect was C) significantly correlated with trial RT.

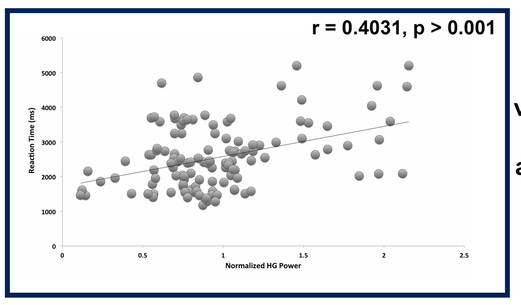
A.



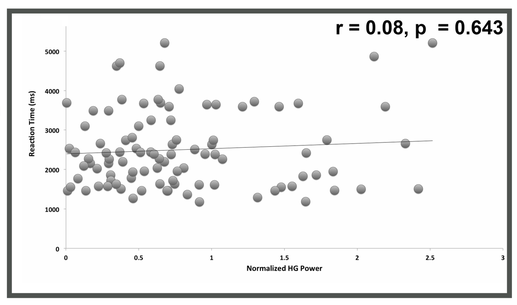
Subject	PPC	RSC	ParaHippo	Entorhinal	PPC	RSC	ParaHippo	Entorhinal
Sbj1	x	x	x	x				
Sbj2					x	x	x	
Sbj3							x	
Sbj4					x		x	
Sbj5		x	x	x			x	x
Sbj6			x	x			x	x
Sbj7		x	x				x	

B.





Trial-based HG values extracted from Posterior Cingulate and retrosplenial cortical electrodes



Conclusions

1) These results potentially suggest that insufficient suppression of neural responses within the left localized medial parietal DMN sites relative to the right has a greater impact on normal linguistic functions.

2) The combination of the ECoG and an abstract-concrete discrimination induces significant spatialtemporal variation, and may provide a reliable spatialtemporal platform to investigate functional variability across low-frequency responses (Miller et al., 2013).

References

1) Anticevic, A., Cole, M. W., Murray, J. D., Corlett, P. R., Wang, X.-J., & Krystal, J. H. (2012). The role of default network deactivation in cognition and disease. Trends in cognitive sciences, 16(12), 584–592. doi:10.1016/j.tics.2012.10.008
2) Binder, J. R., Westbury, C. F., McKiernan, K. A., Possing, E. T., & Medler, D. A. (2005). Distinct brain systems for processing concrete and abstract concepts. Journal of cognitive neuroscience, 17(6), 905–917.
3) Dastjerdi, M., Foster, B. L., Nasrullah, S., Rauschecker, A. M., Dougherty, R. F., Townsend, J. D., Chang, C., et al. (2011). Differential electrophysiological response during rest, self-referential, and non-self-referential tasks in human posteromedial cortex. Proceedings of the National Academy of Sciences of the United States of America, 108(7), 3023–3028. doi:10.1073/pnas.1017098108
4) Miller, K. J., Foster, B. L., & Honey, C. J. (2012). Does rhythmic entrainment represent a generalized mechanism for organizing computation in the brain?. Frontiers in computational neuroscience, 6.
5) Ossandón, T., Jerbi, K., Vidal, J. R., Bayle, D. J., Henaff, M.-A., Jung, J., Minotti, L., et al. (2011). Transient suppression of broadband gamma power in the default-mode network is correlated with task complexity and subject performance. The Journal of neuroscience: 31(41), 14521–14530. doi:10.1523/JNEUROSCI.2483-11.2011