Exploring Intervoxel Dependencies in Human Pharmacological FMRI Data

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INTRODUCTION: Pharmacological FMRI in humans involves BOLD signal acquisition during and after the administration of a drug, and often results in a heterogeneous pattern of drug-induced hemodynamic responses in the brain. Exploratory techniques, including blind source separation, can be useful for BOLD data that contains patterns of cross-dependencies. Bayesian Source Separation (BSS) is a multivariate technique used to calculate the presence of unobserved signal sources in measured FMRI data, as well as the covariance between voxel timecourses [1]. In this study, BOLD measurement of the acute effect of an intravenous dose of cocaine, a substance shown previously to engage multiple sites within the orbitofrontal cortex (OFC) [2], was processed with BSS to find intervoxel correlation statistics. Unlike conventional correlation analysis, this technique does not assume independence between voxel time series.

METHOD: Acute cocaine BOLD data was collected from cocaine-dependent human subjects as described previously (1.5 Tesla, 20 min scan, 64 x 64 x 5mm, infusion after 7 min, 150 time points) [2], generating a pattern of regionally-specific postinfusion BOLD inflections throughout the OFC (Figures 1, 2). BSS was then employed on 144 voxels of BOLD data from the 4 regions of interest in the OFC, utilizing a hemodynamic drug response model with a linear noise term, as described previously [3]. The mechanics of BSS for systems with known (noise trends) and unobserved (neural cocaine response) are available in detail [4]. Posterior estimates for covariance (following application of Bayes rule and Gibbs sampling) were converted into a correlation matrix (Figure 3) and thresholded at $p < 0.05$ ($t = 1.66$, Figure 4).

RESULTS AND DISCUSSION: Figure 3 depicts strong dependencies between voxels of the same region within Regions 1, 2 and 3. Although interregional correlation exists throughout the OFC (strongest between Regions 1 and 3), only positive correlation scores remain statistically significant (Figure 4). The utility of BSS for exploring the spatial structure within human pharmacological FMRI data is thus demonstrated.

REFERENCES: 1. Rowe, MRM 2001. 2. Kufahl et al., ISMRM 2003 (abs. 9). 3. Kufahl et al., MRM 2003 (abs. 1811). 4. Rowe, C & H. 2003.

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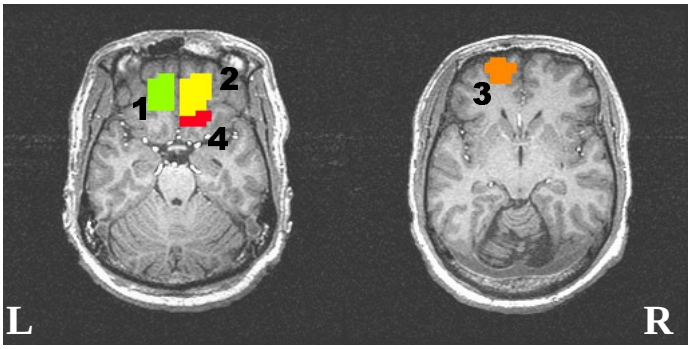

Figure 1. OFC Regions of interest in BSS analysis. 1. left medial orbital gyrus (green) **2.** right medial orbital gyrus (yellow) **3.** left frontal pole (orange) **4.** right posterior orbital gyrus (red).

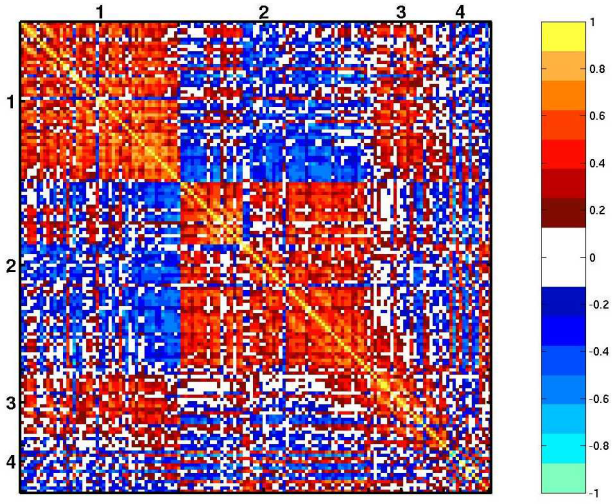

Figure 3. Posterior estimates of intervoxel correlation. Voxels are grouped by region as shown on the axes. Blue pixels correspond to negative correlation, red and yellow pixels denote positive correlation.

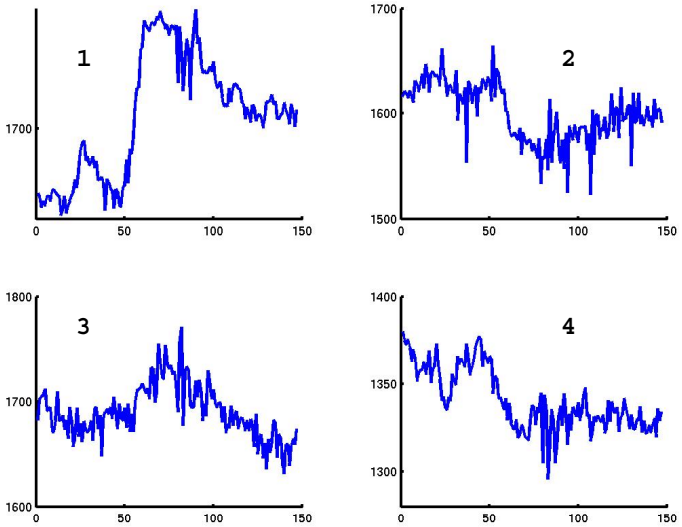

Figure 2. Regional mean BOLD timecourses. Time series are enumerated as in Figure 1. Cocaine infusion occurs at time point 50. Vertical axes are in arbitrary units.

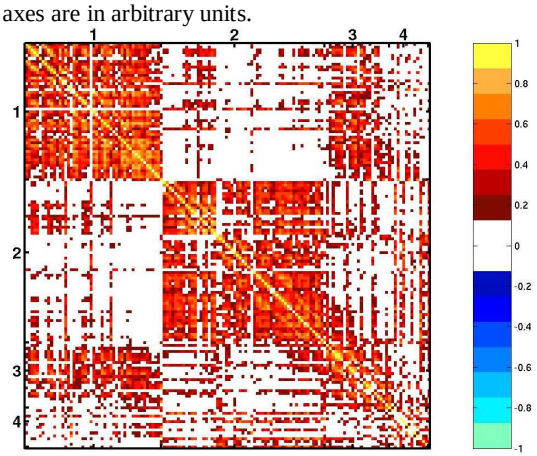

Figure 4. Intervoxel correlation matrix at $p < 0.05$ threshold.