**METHODS**

The goal of the simulation study is to examine the validity of using principal component analysis for accurately predicting the V1 responses in real experimental settings. To bolster realism in the simulation, we incorporate experimental data and parameters from prior experiments whenever possible. In particular, the two factors that are important for determining the success and failure of PCA - 1) the size and the geometry of the cortex that is activation and 2) the orthogonality of the measured time courses. The determination of the physiological geometry of cortical activation is performed with retinotopic f/MRI experiment (Ales et al. 2009) and is described in the f/MRI section. The f/MRI retinotopy is accurate to 2 mm of true activation, and should provide the simulation with ample realism.

**SOURCE LOCALIZATION WITH MRI and fMRI**

We have divided the 20 subjects into 2 groups of 10 subjects. The first group was presented with a stimulus with inner angle of 1.5 degrees and outer angle of 4 degrees. The latter was presented with 1.5 and 7 degrees inner and outer radius, respectively.

Refer to Ales 2009 for details.

**THE PATCH FORWARD SOLUTION**

The bulk of detectable visual evoked potentials are generated by groups of pyramidal neurons located at the midpoint between the outer surfaces of the gray and the white matter and the orientations of these neurons are aligned perpendicular to the cortical surfaces. Given the above generalization, the forward solutions in our boundary element models are produced as follows. First, based on the individual T1-weighted MRI scans, 3-layer segmentation is generated defined by the surfaces of the scalp, gray, and white matter. The initial segmentation is performed using the Freesurfer software package (Dale et al., 1999; Fischl et al. 1999a) and resulted in approximately 150,000 mesh points per hemisphere at nearly uniform density. Typically, this number is sufficient for producing accurate and smooth cortical representation. Each mesh point is defined by the following parameters:

1) a position vector with an arbitrary origin located at the center of the brain **(P)**

2) an orientation vector that denotes the normal to the cortical surface at the mesh position **(M)**

3) a scalar value denoting the area weights associated with the point **(a)**.

Note that if the discrete sampling of the cortical surfaces were done at exactly uniform density, then every area weighting value would be identical.

While the exact values of conductivities are variable between individual subjects, we have assumed the conductivities values of (XX, YY, ZZ) for the scalp, gray, and white matter segmentations as described in (XYZ, 1990) for all subjects. Ideally, we calculate the lead fields in the x-, y-, and z- directions for each anatomical mesh points available in the segmentation using the method described in (Nunez, 1990). The calculation of the lead field is computationally taxing, however, particularly for high throughput analyses involving multiple subjects. In an effort to balance the accuracies of forward solutions and the required computation time, we initially generate the lead fields only on a subset of the anatomical mesh points that we call the seed points. There are 10,242 seed points per hemisphere per subject. The calculation of the lead fields on the seeds was performed using MNE suite (Oostendorp and Van Oosterom, 1992).

To give a measure of mesh densities in physical dimensions, a 1 cm by 1 cm patch on the cortex is represented by approximately 170 mesh points. With the subsampling, approximately 12 of these are seeded, and contain their own calculated lead fields. The lead field values are then interpolated to all of the remaining mesh points. For simplicity, the interpolation is done with a routine that assumes the lead field value of the nearest neighboring seed. Due to the smoothness of the lead fields in the 3 cardinal directions, we believe this is a relatively accurate and fast interpolation scheme. As a result we have interpolated forward solution for the entire anatomical mesh points which is accompanied by accurate surface normal definitions.

To simulate the experimental data, we use the ‘patch forward solution.’ In conventional simulation and source estimation studies, the M/EEG data is generated by simulating an equivalent dipole at a discrete location occupying zero physical area. In reality, a stimulus shown as a patch in visual field, such as multifocal dartboard, activates a measurable area on the visual cortex. The cortical patch representing the stimulus resides on a highly convoluted surface and the changes in orientation within its boundaries are complex and variable. The complexity and individual variability of these folding patterns must be taken into consideration when discussing the utility of source estimation methods. We suspect that simulating a dataset based on the activation of the entire cortical patch instead of the simplified equivalent dipole provides a more realistic method for simulating experimental data.

The increased realism of the forward model comes with a small computation cost since the calculation of patch forward solution is simple. It is simply the weighted sum of all individual forward solutions contained by the cortical patch. As an example, suppose a cortical patch representing a visual stimulus consists of *n* mesh points. Thus there are *n* associated individual lead fields L1, L2 … Ln, the orientation vectors M1, M2 … Mn, and the area weighting scalars a1, a2 … an. The forward solution per mesh point is the inner products between the normal vector and the lead field scaled by the area weighting values. The sum of all the contained forward solutions becomes the patch forward solution.

Finally, we note the importance of generating the lead fields for the high density mesh via the interpolation step. The accuracy of patch forward solution depends heavily on the interplay of the orientation vectors. For a large patch, such as the 32-patch dartboard stimulus, the cortical activation is spanned by approximately 1x1cm2 area. Due to the extreme curvature in the occipital cortex, significant cancelation of the signal occurs at the sensors. When we use insufficient number of mesh points, the cancelation of the sources may occur improperly and result in simulated topographies that are unrealistically biased. By using all available orientation values that adequately reconstruct the cortical structures we can simulate the most representative data.

**SIMULATION OF EXPERIMENTAL DATA**

Stimulus

We simulate the EEG data in response to a check reversing 96-patch multifocal stimulus composed of 24 spokes and 4 rings (Figure. XYZ). A patch consists of 2 by 4 checks in tangential and radial directions with alternating white and black checks. The reversal of the checks produces visual evoked potential time locked to the reversal onset. Except for their respective spatial locations, every patch is assumed to be qualitatively identical and is expected to produce identical time course.

The Activation Area

A major concern in simulation experiment is determining how many sources to choose and where to place them. The sources should include the basic visual sources such as V1, V2, and V3, but

There are a The defining the time courses for the visual sources is somewhat uncertain as there are no ways of non-invasively measuring temporal activation of visual sources in human subjects. The recent work by Ales et al., provides what is likely the most accurate approximations of V1 and V2 visual sources using the multifocal dartboard stimulus. We have chosen the V1 and V2 time courses

Signal to Noise

SIGNAL AND TOPOGRAPHY ANALYSIS

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