Cortical Folding as a Sparseness Criterion for Identifying VEP Sources

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Evaluation of Cortical Folding:
When a region of activation moves around a cortical fold in response to a neighboring stimulus patch the scalp topography is expected to change dramatically. Shown to the left are scalp topographies for each of the 96 stimulus patch locations at a single time point. Abrupt topography changes are evident such as between ring 1, location 8 and ring 2, location 8. This difference is confirmed by the negative correlation coefficient between these two patch topographies, as given by the red bar separating the patches. The correlation coefficient between adjacent scalp topographies was used as a quantitative approximation of topography similarity between the responses to adjacent patches. In the plot to the left, the colored bars indicate the correlation coefficients between adjacent scalp topographies. The blue and red extremes of the color scale used for the correlation bars indicate topography correlations of 1 and -1 respectively. In the plot to the left, the colored bars indicate the correlation coefficients between adjacent scalp topographies.

Results of Principal Component Analysis:
Shown below are various linear combinations of the two dominant components determined via SVD. Note that the different rotation angles produce varying degrees of evidence of cortical folding. It is expected that some subset of the linear combinations of the principal components will yield the topographies of independent sources (possibly V1 and V2).

Discussion:
Spectral cortical folding was observed in a subset of the temporal data as well as in a subset of the topographic maps attained through linear combinations of the two dominant SVD components. Application of source localization to topographies displaying a sparsity of cortical folding yielded improved results. Finding a rotation that effectively silences all but one cortical source could greatly improve the ability to localize that source.

Background:
Source localization remains an unsolved problem largely due to the proximity of early visual areas and the convoluted cortical geometry. For example, given the retinotopic mapping from stimulus space to cortical space shown below, consider stimulus patches 7 & 8 that evoke a responses in corresponding cortical areas V1 and V2. In V1 areas 7 and 8 would generate very different topographies whereas representations in V2 of regions 7 and 9 would generate very similar topographies. When multiple cortical areas are active simultaneously, localization of the underlying sources becomes difficult if not impossible. However, we can use a sparseness criterion to identify time points when a single source dominates to aid in source localization.

Stimulus:
The stimulus subtended 18 degrees. It consisted of a dartboard pattern containing 96 checkerboard patches. Each patch was cortically scaled to activate about 30 mm2 of primary visual cortex and modulated according to a binary m-sequence.